EFFECT OF SODIUM HYPOCHLORITE ON THE PUSH-OUT BOND STRENGTH OF BIODENTINE AND ENDOSEQUENCE BIOCERAMIC ROOT REPAIR MATERIAL ON FURCAL PERFORATION – AN IN VITRO STUDY

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In partial fulfillment for the degree of

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BRANCH – IV

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2015 - 2018

ENDORSEMENT BY THE H.O.D. PRINCIPAL / THE HEAD OF THE INSTITUTION

This is to certify that **Dr. ABITHA BANU.M.,** Post Graduate student (2015–2018) in the Department of Conservative Dentistry and Endodontics, K.S.R. Institute of Dental Science and Research, has done this dissertation titled **"EFFECT OF SODIUM HYPOCHLORITE ON THE PUSH-OUT BOND STRENGTH OF BIODENTINE AND ENDOSEQUENCE BIOCERAMIC ROOT REPAIR MATERIAL ON FURCAL PERFORATION – AN IN VITRO STUDY"** under our guidance and supervision in partial fulfillment of the regulations laid down by **The Tamil Nadu Dr. M.G.R. Medical University**, Chennai – 600 032 for **M.D.S.,** (Branch – IV) **CONSERVATIVE DENTISTRY AND ENDODONTICS** degree examination.

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TITLE OF DISSERTATION	**EFFECT OF SODIUM HYPOCHLORITE ON THE PUSH-OUT BOND STRENGTH OF BIODENTINE AND ENDOSEQUENCE BIOCERAMIC ROOT REPAIR MATERIAL ON FURCAL PERFORATION – AN IN VITRO STUDY**
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INTRODUCTION

INTRODUCTION

The success of endodontic therapy solely depends on thorough chemomechanical preparation and three dimensional obturation of the root canal system. The pivotal aim of endodontic therapy is to procure a “hermetic seal”. [1]

Perforations can occur while performing endodontic treatment in tooth with caries, resorption, while preparing post space or it can be iatrogenically produced. [2,3] The perforations are nothing but a artificial communications that are created in root canal environment with the supporting structures of teeth or to the oral Cavity. [4]

The perforation area prognosis mainly depends on the size, location, site and time of occurrence and also depends on material that are used for perforation repair. Successful management of furcal perforations poses a challenge for a clinician. [5] Ideally, to obtain a agreeable prognosis the perforation site should be instantly sealed without any delay with a ideal perforation repair material. This aids in preventing unwanted communication with external fluids or vice versa. [6,7]

There are variable dental materials have been tried and proposed for perforation repair by endodontic therapy. It includes zinc oxide eugenol cement, silver amalgam, phosphate based cements, gutta-percha, calcium hydroxide, glass-ionomer cement (GIC), and resin modified glass ionomer. [8]

However, none have been able to satisfy all the requirements of an ideal endodontic repair material. In this study, Biodentine (BD) and Endosequence Root Repair Material (ERRM) had been selected as a furcal perforation repair material.

Studies conducted by M.B. Guneser (2013) [2]and A Elnaghy (2014) [9] suggested that Biodentine had significantly higher bond strength as compared to Mineral Trioxide Aggregate (MTA) when exposed to regularly used irrigating solutions such as sodium hypochlorite (NaOC), ethylene diamine tetra acetic acid (EDTA), chlorhexidine (CHX) and saline. Hence, Biodentine has been selected as a furcal perforation repair material in comparison with Endosequence Root Repair Material.

Biodentine (Septodont, Saint Maur des Fosses, France) is a calcium silicate-based cement that can be used as a dentin substitute on crowns and roots. Biodentine consists of powder and liquid. The components of powder mainly include tricalcium and dicalcium silicate, and the liquid comprises of calcium chloride. The provided liquid is emptied over the powder contained in a capsule, which is the subjected to mechanical manipulation using triturator. The final setting time of biodentine is approximately 10 to 12 minutes. The addition of calcium chloride to the provided liquid attributed to short setting time of biodentine. Biodentine has the advantages of biocompatibility, [10] ability to seal good[11], bioactivity,[12] and also which has higher compressive strength.[13]

The next material selected to compare with biodentine was Endosequence Root Repair Material (Brasseler USA, Savannah, GA, USA), a new bioceramic material. It is a hydrophilic, insoluble, radiopaque, and aluminum-free material composed of calcium silicates, zirconium oxide, tantalum oxide, calcium phosphate monobasic, and filler agents.

It is delivered in two forms of premixed product, the first one is low viscosity syringe material for easy dispending. The next is high viscosity putty form.

Moisture is required for the material to set and harden. It has longer working time of more than 30 minutes. Under normal conditions the material sets by 4hours. ERRM has an alkaline pH, [14] It is biocompatible, [15,16] antibacterial, [17] and able to seal root-end cavities [18].

After furcal perforation repair, endodontic treatment is performed using various irrigants. Most commonly used endodontic irrigants are sodium hypochlorite (NaOCl), 2% chlorhexidine,17% ethylene diamine tetra acidic acid and saline. They can be used to disinfect the root canal system.[19,20]

However, after perforation repair made with suitable material. The contact of irrigants with the perforation repair materials is unavoidable. Thus, this study was conducted to evaluate the push-out bond strength of Biodentine and Endosequence Root Repair Material in the presence of 3.5% NaOCl and saline.

AIM AND OBJECTIVES

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AIM:

To evaluate the effect of sodium hypochlorite on the push-out bond strength of Biodentine (BD) in comparison with Endosequence root repair material (ERRM) on furcal perforation.

OBJECTIVES:

1. To compare and evaluate the push out bond strength of Biodentine (BD) and Endosequence root repair material (ERRM) after 30 minutes' immersion in commonly used endodontic irrigants such as sodium hypochlorite and saline.

2. To compare and evaluate the nature of bond failure in Biodentine and Endosequence root repair material (ERRM) after immersing the samples in two commonly used endodontic irrigants such as sodium hypochlorite and saline.

3. To evaluate the changes in microstructural characteristics of specimens, under a scanning electron microscope after they were surface treated with two commonly used endodontic irrigants such as sodium hypochlorite and saline.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Emine C. Loxley et al [21] (2003), evaluated the effect of intracanal oxidizing agents on the strength of materials used to repair root perforations. They standardized the perforation size in bovine root samples and repaired the perforation with mineral trioxide aggregate (MTA), Super-EBA cement (S-EBA), or intermediate restorative material (IRM). After 7 days, 10 samples from each group were analyzed for push-out bond strength with an instron machine (control group). The remaining samples were immersed in NaOCl, sodium perborate mixed with saline (SPB+S), superoxol (SO), sodium perborate mixed with Superoxol (SPB+SO), or saline for 7 days to investigate the effect of irrigants and walking bleach compounds on the perforation repair materials. The samples were evaluated using push-out bond strength in comparison with those of the dry materials to determine whether any loss of integrity had occurred. On exposure to various oxidizing agents IRM performed consistently, whereas MTA showed reduced resistant to dislodgement forces on compared with IRM and S-EBA. When immersed in sodium perborate bleaching solutions MTA was more affected than IRM.

Lee YL et al [22] (2004), determined the influence of various physiological environments on the hydration behavior and physical properties of mineral trioxide aggregate (MTA) using scanning electron microscope, X-ray diffraction (XRD) and micro hardness tests. MTA samples were hydrated in distilled water, normal saline, pH 7 and pH 5 respectively. Normally the microstructure of MTA consists of cubic and needle-like crystals. Whereas on evaluation pH 5 groups showed no needle-like crystals and erosion of cubic crystal surface was evident. The pH 5 specimen's micro hardness was also significantly weaker compared to the other three groups ($p<0.0001$). The findings of this study showed evidence that an acidic environment of pH 5 adversely affects both the physical properties and the hydration behavior of MTA.

Ping Yan et al [20] (2006), conducted an in-vitro study to evaluate the effect of commonly used endodontic irrigants on the bond strength of MTA-dentine. Standardized dentine disks were prepared to a thickness of 1mm in mid-root dentine, and the central hole in each disk was about 1.3mm in diameter. The perforation was filled with mineral trioxide aggregate (MTA). Then, the specimens were randomly divided into four groups and immersed in saline, 5.25% NaOCl, 2% chlorhexidine and glyde file prep for 2 hours. The bond strength was measured using material testing system (MTS). The fractured root surfaces were observed under scanning electron microscopy. The results showed that in comparison with the control group, the bond strength was significantly lower in glyde file prep group and there was no significant difference in the chlorhexidine or sodium hypochlorite groups. They concluded that, the glyde file prep on SEM evaluation showed regular flake-shaped materials on the interfacial layer. This infiltrate into the interfacial layer interferes with the chemical adhesion between MTA and dentine. Another reason could be the demineralization effect of Glyde File Prep on Ca-containing materials. Because of the porous nature of MTA, [23] the precipitation proceeded internally within MTA to change the microstructure of MTA and thus negatively affects the bond strengths of MTA-dentine.

Jack B. Smith et al [24] (2007), examined the effect of calcium-depleting endodontic irrigants such as ethylene diamine tetra-acetic acid (EDTA) and BioPure MTAD on the dissolution, surface characteristics and ultra structural change of white mineral trioxide aggregate (MTA). The methodology includes MTA condensed into cylindrical wells created in plexiglass platforms, allowed to harden completely before initial treatment with 1.3% NaOCl and final treatment with 17% EDTA for 5 minutes, or BioPure MTAD for 1, 3, or 5 minutes. Analysis of the mean depth of materials removed was evaluated using three-dimensional profilometry. The results of this study suggested that BioPure MTAD- treated MTA surfaces exhibited higher surface roughness and showed more calcium depletion when compared with EDTA treatment. There is increased roughness and decomposition of the particle-binding hydration phase of white MTA after treating with BioPure MTAD. Thus, BioPure MTAD as a final rinse negatively influences the hydration phase as well as sealing property of MTA-repaired perforations in root dentine.

Lee YL et al [25] (2007), assessed the effect of Ethylene diamine tetra acetic acid (EDTA) which is a commonly used material in negotiation of calcified canals which might result in risk of root perforation which are often repaired using mineral trioxide aggregate (MTA). After repairing the defect with suitable perforation repair material, the repair material has been contacted with commonly used irrigants. The study was evaluated under scanning electron microscopy and energy-dispersive x-ray spectroscopy. They concluded that MTA specimens stored in EDTA showed no crystalline structure and ca/Si molar ratio were also considerably decreased when compared to the specimens stored in distilled water and normal saline. In addition to this it showed poor cell adhesion in EDTA-treated MTA group. X-ray diffraction indicated that the peak corresponding to portlandite, which is normally present in hydrated MTA, was not shown in the EDTA group. Micro hardness of EDTA-treated group was also significantly reduced ($p<0.001$). These findings suggest that EDTA interferes with the hydration of MTA, decreases its hardness and results in poor biocompatibility.

Uyanik MO et al [26] (2009), evaluated the effect of different endodontic irrigation regimens and its influence on sealing ability of repaired furcal perforations. Study design includes 90 extracted molar teeth decoronated and perforations were created in the center of the pulp chamber floor. Eighty teeth were randomly divided into two groups, 40 samples of mineral trioxide aggregate (MTA) and 40 samples Super-EBA. The remaining 10 teeth served as control. The specimens were further sub grouped according to the irrigation regimens applied over the repair site (n = 10/group): (a) 5.25% NaOCl, (b) 5.25% NaOCl +EDTA, (c) 5.25% NaOCl + MTAD, and (d) No irrigation. Coronal leakage was measured by the fluid-filtration method at 1 day and 1 week. The results suggested that, fluid conductance was not affected by the type of repair material ($P = .964$) or time ($P = .726$), but was affected significantly by the irrigation regimens in the following ranking: (P less than .001): NaOCl less than or equal to No Irrigation. No Irrigation less than NaOCl and MTAD. NaOCl and MTAD less than or equal to NaOCl and EDTA. Thus, sealing ability of furcal perforations repaired with MTA and Super-EBA were differentially affected on exposure to different tested irrigation regimens.

Saghiri et al[27] (2010), performed a study is to evaluate the push-out strength of white mineral trioxide aggregate (WMTA) on various alkaline pH values. They prepared samples of about 1mm thickness using a diameter of 1.3mm. They had taken single - rooted teeth from which mid root dentine are sliced in cross sectiona. The specimens were randomly divided into 4 groups (n=20), immersed in synthetic tissue fluid (STF) (pH, 7.4), STF buffered in potassium hydroxide at pH values of 8.4, 9.4, or 10.4 respectively. They are incubation at 37^0C for 3 days then the specimens were subjected to push - out bond strength analysis followed examination at X40 magnification under light microscope. Then, the data was statistically analyzed. They concluded that greatest mean push-out bond strength (9.46) was observed after exposure to pH values of 8.4 and lowest mean push-out bond strength (5.68) was observed after exposure to pH values of 10.4. Thus, the different alkaline pH ranges influence the bond strength of White Mineral Trioxide Aggregate.

Seong-Tae hong et al[28] (2010), conducted an in vitro study using a perforated model design. Perforations repaired made with MTA, which contains with 10% $CaCl_2$ with or without was condensed and allowed to initial set for 10 minutes. The samples were randomly divided into 4 groups (n=10), group 1- with or without 10% $CaCl_2$ of MTA immersed in 3.5% sodium hypochlorite (NaOCl) or group 2- with or without 10% $CaCl_2$ of MTA immersed in 2% chlorhexidine gluconate (CHX). After 30 minutes of immersion all the samples are allowed to set for 48 hours. In control group a wet cotton pellet was placed over the samples. Resistance against displacement was recorded. Morphological alterations of surface characteristics were examined under scanning electron microscope (SEM). Changes on chemical elements of the materials were examining under energy dispersive x-ray spectroscope (EDS). They concluded that, accelerated MTA groups showed better result than non accelerated MTA. They resulted in fast setting action along with improved physical property. As well as better resistance against dislodgment forces without alteration in crystalline surfaces. So, this can be a material of choice in endodontic therapy during single visit

Noushin Shokouhinejad et al [29] (2010), in their study They prepared samples of about 1mm thickness using a diameter of 1.3mm. They had taken single - rooted teeth from which mid root dentine are sliced in cross section. To repair the perforation area ProRoot MTA was used, which is mixed with 0.33g of distilled water. The samples were divided into four groups (n=20) and wrapped in pieces of gauze and soaked in phosphate buffered saline solution (pH = 7.4) and butyric acid buffered at pH values of 4.4, 5.4, or 6.4, respectively. The samples were incubated at 37 ^{0}C for 4 days. The universal testing machine was used to examine the push-out bond strength of the samples. At X40 magnification the mode of bond failure was analysed under light microscope. In summary, the force needed for displacement of MTA was significantly lower in samples stored at lower pH value of 4.4 than the samples stored in 5.4 and 6.4. The inspected samples revealed predominantly adhesive mode of bond failure.

Vivek Aggarwal et al [30] (2011), evaluated the effect of various endodontic solutions on micro hardness and flexural strength of specimens sealed with white mineral trioxide aggregate. Twenty-five disk-shaped and 25 bar-shaped specimens were randomly divided into five groups and were stored is distilled water, NaOCl (5.25%), chlorhexidine

CHX (2%), EDTA solution (17%) and BioPure MTAD for 7 days. Specimens were examined for micro hardness test using a Knoop diamond indenter. Flexural strength analysis using universal testing machine was performed. On statistical analysis EDTA and BioPure MTAD showed significant reduction in micro hardness as well as flexural strength in comparison with other groups. Thus, a final flush with distilled water is always advocated before MTA placement especially if decalcifying agents were used for clinical procedure.

Ahamed Abdel Rahman Hashem et ali [31] (2012), in their study used 80 human mandibular molars. Perforations were made in the furcation area using #4 Peeso drills. The perforation was repaired using Mineral trioxide aggregate (MTA) and bioaggregate (BA). The samples were randomly divided into 4 groups (n=10) according to storage media and time. Group A: phosphate-buffered saline (PBS) (pH = 7.4) for 4 days, Group B: acetic acid (pH = 5.4) for 4 days, Group C: PBS for 34 days, and Group D: acetic acid (pH = 5.4) for 4 days followed by exposure to PBS for 30 days. The Push-out bond strength was analyzed using universal testing machine. Then the specimens were vertically split into 2 halves to examine the walls of the perforation site using scanning electron microscopy (SEM). This study concluded that the acidic pH negatively influences MTA than bioaggregate. Storage in PBS for 30 days effectively reverses the affected bond strength of MTA by an acidic environment.

Davut Çelik et al [32] (2013), in their study sectioned one hundred eighty root samples of about 2mm thickness. The samples were prepared and randomly divided into 4 groups mainly. DiaRoot BioAggregate, MTA-Angelus, MM-MTA (hand-mixing) and MM-MTA (auto-mixing). After perforation repair with the above mentioned materials all the samples were immersed in 1 % NaOCl for 3 min, 17 % EDTA for 3 min followed by 1 % NaOCl. In the control group no irrigation was performed. The samples were incubated for 7 days at 37^0C and examined using universal testing machine for push-out bond strength analysis. They concluded that the resistance to displacement by MM-MTA (auto mixing) was similar in comparison with other groups.

Noushin Shokouhinejad et al [33] (2013), in their study sectioned one hundred and twenty root slices with a center lumen of about 1.3mm diameter. The perforated site was repaired with ProRoot MTA, Bioaggregate (BA) and Endosequence Root Repair Material ERRM. The specimens were randomly divided into 2 groups, and immersed in PBS for 1 week or 2 months. The push-out bond strength and mode of failure was analyzed using universal testing machine and stereomicroscopy respectively. The scanning electron microscopy (SEM) evaluation was performed for analysis of structural change. From this study, they presumed that ERRM had significantly higher bond strength to root canal walls when compared to MTA and BA. Increased incubation time significantly improved the bond strength and bioactive reaction of all bioceramic materials.

Guneser et al [2] (2013), prepared dentin disks from mid root dentin of canine teeth of about 1mm thickness. The lumen was enlarged to a diameter of 1.4mm. The samples were randomly divided into following 5 groups and following materials were placed respectively, Biodentine, ProRoot MTA, Amalgam, Dyract AP, and intermediate restorative material (IRM). The specimens were further divided into 3 subgroups and immersed in 3.5% sodium hypochlorite, 2% chlorhexidine gluconate (CHX), or saline for 30 minutes. In the control group no irrigation was done (n = 10). A wet cotton pellet was wrapped over each specimen and incubated for 48 hours. The push-out bond strength and nature of bond failure were analyzed using universal testing machine and stereomicroscope respectively. The conclusion of this study was that biodentine performed consistently even after exposure to different endodontic irrigants, where as MTA showed the lowest push-out bond strength to root dentin.

Nagas E et al [6] (2013), evaluated the push-out bond strength of mineral trioxide aggregate (MTA) after exposure to different irrigants. Dentin disks of 1 mm thickness were used to prepare specimens with a lumen of standardized diameter of 1.3mm. Then the specimens were randomly divided into 4 groups based on the irrigation solution used. Group 1-10 ml of 5.25% NaOCl for 10 min; Group 2-10 ml of 5.25% NaOCl for 10 min, followed by 5 ml of 17% EDTA for 5 min; Group 3-10 ml of 5.25% NaOCl for 10 min, followed by application of 5 ml of 1% Per acetic acid (PAA) for 5 min; and Group 4-no irrigation. The push-out bond strength was analyzed using universal testing machine followed by stereomicroscopic evaluation to examine the nature of bond failure. They, concluded that exposure of repaired root perforations to 5.25% NaOCl, 17% EDTA, or 1% PAA does not alter the dislocation resistance of MTA at different locations of root dentin and nature of bond failure was predominantly adhesive.

Sobhnamayan et al [34] (2014), performed an in - vitro study which includes 60 root-dentin slices from single rooted teeth prepared with the lumen diameter of 1.3mm. The perforation was sealed with Calcium-enriched mixture (CEM) mixed with the provided liquid (group 1 and 3) and CEM mixed with 2% chlorhexidine (group 1 and 2). The Groups 1 and 2 specimens were incubated at 37^0 C for 3 days and (groups 3 and 4) for 21 days. The dislodgment resistances of the groups were evaluated using universal testing machine, and nature of bond failure was examined under a light microscope at 40X magnification. In summary, adverse effect on bond strength was observed on addition of 2% CHX. The bond failures in all the groups were predominantly of cohesive type.

Elnaghy et al [9] (2014), evaluated the micro push-out bond strength of Biodentine (BD) and white mineral trioxide aggregate (WMTA) on exposure to QMix and other endodontic irrigants. Perforated sites were prepared using bioceramic materials. The specimens were randomly divided into 6 groups (n=15) according to the irrigating solution: saline, 5.25% NaOCl, 2% CHX, 17% EDTA, and QMix immersed in the respective irrigants for 30 min. No irrigation was performed on the control group. The Push-out bond strength analyzed using universal testing machine followed by stereomicroscopic evaluation to examine nature of bond failure. The morphological

Characteristics changes of the specimens were evaluated using the scanning electron microscopy (SEM). They concluded that QMix did not affect the bond strength of BD or WMTA. Biodentine showed higher resistance against dislodgement forces from root dentin. The Nature of bond failure in BD were cohesive, while for WMTA, failure was predominantly of adhesive type.

Yahya et al [35] (2015), prepared dentin disks from mid root dentin of canine teeth of about 1mm thickness. The lumen was enlarged to a diameter of 1.4mm. The samples were divided into 3 groups, following materials were placed Biodentine, MTA, and GIC. The specimens were further divided into 3 subgroups according to specimen immersion. The prepared samples were immersed in QMix, Bio Pure MTAD and saline solutions for 30 minutes. No irrigation was performed on the control group. After 48 hours of incubation, Push-out bond strength was analyzed using universal testing machine followed by stereomicroscopic evaluation to examine the nature of bond failure. In conclusion the force needed for dislodgement of biodentine needs higher dislodgement forces to displace when compared with MTA and GIC.

Agrafioti et al [11] (2015), prepared dentine disks with a lumen measuring 1.3mm in diameter and packed. The samples were divided into equal groups and repaired with biodentine and ProRoot MTA respectively. 20 specimens from each group were randomly divided into two groups according to the storage medium. Group A: comprises of material with saline as storage medium; Group B: comprises of material with citric acid buffered at pH 5.4 as storage medium. The sealing ability was evaluated using a fluid transport model at 1, 3, 6, and 24 hrs and 1 or 3 months' intervals to examine endodontic microleakage. The morphological alterations were evaluated using scanning electron microscopy. The morphological changes of biodentine samples were well evident on exposure to acidic environment than MTA samples. The MTA showed good sealing ability, preventing fluid movement over time in both environments.

Singh, et al [19] (2016) in their study evaluated 46 human premolar teeth with single roots. The perforations were made on mid-root area using #5 Peeso drills. The Perforation was repaired using Biodentine and Mineral trioxide aggregate (MTA). The samples were randomly divided into 2 groups which were further divided into 3 subgroups according to the irrigants used for immersion. The Biodentine and MTA samples were immersed in 3% NaOCl and 2% CHX for 30 min respectively. No irrigation was performed in the control groups. A wet cotton pellet was wrapped over each specimen and the specimens were incubated for 48 hours. The push-out bond strength and nature of bond failure were analyzed using universal testing machine and stereomicroscope respectively. They concluded that, biodentine showed significantly higher push-out bond strength in the presence of both NaOCl and CHX in comparison with MTA. Whereas, the MTA samples immersed in CHX had reduced push-out bond strength when compared with samples immersed in NaOCl.

Sadegh et al [36] (2016), in their study used mineral trioxide aggregate (MTA) which was packed into a prepared lumen space of diameter 1.3mm. They divided the samples into 4 groups depending on the irrigants used. Group 1- Smear Clear, Group 2 - 2.5% sodium hypochlorite (NaOCl), Group 3 - 2% chlorhexidine (CHX) and Group 4 - saline as commonly used root canal irrigants. All the samples were incubated for 48 hours and examined using universal testing machine for push-out bond strength analysis. Stereomicroscope was used to determine the mode of failure. They concluded that there was no significant difference in the bond strength of the MTA samples irrespective of the irrigants used.

Nagas Emre et al [37] (2017), conducted a study is to evaluate the effect of laser-activated irrigation (LAI) of NaOCl on the push-out bond strength of bioceramic material in furcal perforations. Standardized furcal perforations of diameter 1.3mm were made on the pulp floor restored with ProRoot Mineral Trioxide Aggregate and Biodentine. The samples were randomly divided into 5 subgroups according to irrigation regimens as follows (a) distilled water with needle irrigation; (b) 5.25% NaOCl with needle irrigation; (c) distilled water with LAI; (d) 5.25% NaOCl with LAI; and (e) no irrigation (control group). The bond strength of the test specimens was assessed using universal testing machine. Eventually, as a perforation repair material Biodentine showed higher dislodgement resistance than ProRoot MTA.

Erbium, Chromium: Yttrium–Scandium–Gallium–Garnet (Er,Cr:YSGG) laser activation of irrigants had no adverse effect on the push-out bond strength of Biodentine or ProRoot MTA.

Sara et al [8] (2017)**,** prepared dentin disks from mid root dentin of single-rooted human teeth (n=144). The dentine disks were randomly divided into 4 groups according to the perforation repair material used. They were ProRoot white mineral trioxide aggregate (PMTA), biodentine (BD), NeoMTA Plus (NMTA), and EndoSequence root repair material fast set putty (ERRMF). Each main group was further divided into 2 subgroups based on immersion, 2.5% NaOCl for 30 minutes, and no irrigation was performed on the control groups. After 48 hours of incubation, the push-out bond strength evaluation was performed using universal testing machine followed by stereomicroscopic examination to record the nature of bond failure. 2 samples were randomly selected from each group and subjected to scanning electron microscopy for analysis of microstructural change. In summary, NaOCl treatment significantly increases the push-out bond strength of PMTA and ERRMF. Whereas, significant reduction of the bond strength was observed in the BD samples and NMTA samples. The predominant mode of failure was cohesive type. Morphological observations revealed cubic crystals on its surface. In, the crystals are considerably reduced in number on ERRMF group. In NMTA group Sodium hypochlorite increased its surface crystallization.

Vandana Gade et al [38] (2017), prepared 60 dentine slices of 2mm thickness with a lumen diameter of 1.3mm. After 24 hours of incubation, the samples were subdivided into 6 groups, distilled water (control), Saline, 17% EDTA, 10% Citric acid, QMix and Glyde

File Prep. After a Post immersion period of 24 hours, the test specimens were subjected to push-out bond strength analysis. They concluded that, the control group showed highest push-out bond strength in comparison with other groups. On compared with other final rinsing agents QMix showed the least negative effect on push –out bond strength of biodentine.

MATERIALS AND METHODS

ARMAMENTARIUM USED IN THE STUDY:

- Extracted lower molars
- Diamond disc and mandrel
- Round diamond abrasive
- Endosequence Root Repair Material (ERRM)- premixed syringe with calibrated intracanal tips (Brasseler USA, Savannah, GA, USA)
- Biodentine- capsule and liquid form (Septodont)
- Sodium hypochlorite 3.5% (VIP Vensons, India)
- Normal saline (Nirlife NIRMA LIMITED)
- Incubator
- Kalpak universal testing machine
- Stereomicroscope (K.S.R Prosthodontic department)
- Scanning electron microscope (Zeiss Sigma V, SITRA COIMBATORE)

MATERIALS AND METHODS:

This experimental study includes 120 extracted mandibular first and second molars which were extracted due to orthodontic and periodontal reasons.

INCLUSION CRITERIA:

- Mesial and distal rooted mandibular first and second molar.
- Tooth with defined furcation width.
- The space between the canal and furcal area should have adequate distance to create perforation

EXCLUSION CRITERIA:

- Uni-radicular teeth
- Caries involvement till furcation area
- Teeth with anomalies
- No fracture or crack in the pulpal floor
- Previous root canal treated tooth

PREPARATION OF THE TEETH:

The Teeth were cleaned immediately after the extraction to remove residual tissues and calculus, and stored in 1% thymol solution until the procedure. Molars were amputated 3 mm below the furcal area using a tapered diamond stone. The crowns of molar teeth were decoronated, canals were located. A horizontal section of about 1.0 mm thickness were made over the pulpal floor by using a water-cooled, low-speed Isomet diamond saw. In each slice, the perforations were made on the furcal area with a 1.4 - mm diameter using a diamond bur. The sectioned samples were randomly divided into three groups, which comprises of 60 samples in each group.

GROUPING:

Group I: Biodentine - BD (60 samples)

Subgroups:

I A- Biodentine immersed in 3.5%NaOCl.

I B - Biodentine immersed in saline.

I C- Biodentine without any immersion (control).

Group II: Endosequence Root Repair Material - ERRM (60 samples)

Subgroups:

II A- Endosequence Root Repair Material immersed in 3.5%NaOCl.

II B- Endosequence Root Repair Material immersed in saline.

III C- Endosequence Root Repair Material without any immersion (control).

MANIPULATION:

Group I: Biodentine liquid from a single-dose container was emptied into a powder-containing capsule and mixed for 30 seconds at 4,000– 4,200 rotations per minute (rpm).

Group II: Endosequence Root Repair Material- premixed syringe with calibrated intracanal tips were used to repair the perforation site without any mechanical manipulation.

PERFORATION REPAIR AND SPECIMEN IMMERSION:

Furcal perforation repair of 120 specimens were made, out of which 60 samples were repaired with biodentine and the remaining 60 samples were repaired using endosequence root repair material. The test materials were incrementally placed into the prepared furcal space of the dentin slices and condensed gently. Excess material was trimmed from the surface of the samples with a scalpel.

Subsequently, the samples were wrapped in wet gauze, placed in an incubator, and allowed to set for 10 minutes at 37^{0}C with 100% humidity. Immediately after incubation, the samples were divided into 6 subgroups, each subgroup contained 20 samples each. Subgroup IA (n = 20) - perforation area was repaired with biodentine and immersed into 3.5% NaOCl (VIP Vensons, India). Subgroup IB (n = 20) - perforation area was repaired with biodentine and immersed in saline solution (Nirlife NIRMA LIMITED). Subgroup IC (n = 20) - perforation area was repaired with biodentine. No irrigation was performed in the controls. Subgroup II A (n = 20) - perforation area was repaired with ERRM and immersed into 3.5% NaOCl (VIP Vensons, India). Subgroup II B (n = 20) - perforation area was repaired with ERRM and immersed in saline solution (Nirlife NIRMA LIMITED). Subgroup II C (n = 20) - perforation area was repaired with ERRM. No irrigation was performed in the controls.

After 30 minutes of immersion on the respective test solutions, all samples were removed washed with distilled water. Then all the specimens were allowed to set for 48 hours at 37^0 C with 100% humidity using an incubator. In control group, a wet cotton pellet was placed over each specimen restored with repair material without any irrigation and 48 hours allowed to set.

PUSH-OUT BOND STRENGTH TEST:

The push-out bond strength analysis was carried out using a universal testing machine (Kalpak universal testing machine, Erode). All the samples were placed on a wooden jig which can be adjusted, according to the size of the sample by a provided screw. The jig contains a small shelf - like area for the placement of the specimens, such that the furcal area was centrally located. This centrally placed furcal area aids in free motion of the plunger with a 1.2 mm diameter, at a constant vertical downward pressure at a speed of 1 mm/min. The plunger tip was positioned in such way, which contacts only on the test material on the furcal area. A load versus time curve was plotted in the real time by a software program connected to the universal testing machine. The test was carried out until total bond failure occurred. The highest force applied to the materials at the time of dislodgement was recorded in Mega Pascal (MPa). The operator, was blinded to the experimental samples to avoid bias.

BOND STRENGTH WAS CALCULATED USING THE FORMULA,

Bond Strength (MPa) = force for dislodgement (N) / Bonded Surface area (mm^2)

Bonded surface area = 2 * p * r * h

*Where **p** is the constant 3.14, **r** is the radius of the perforated area, and **h** is the thickness of the dentin slice in millimeter*.

After the push-out bond strength test was performed, each specimen was examined under stereomicroscope to assess the nature of bond failure. The mode of bond failure was categorized under 1 of the 3 modes. The modes of bond failure are as follows,

1. Adhesive failure (Perforation repair material and dentine interface)
2. Cohesive failure (Within the perforation repair material)
3. Mixed failure (Both adhesive and cohesive failure)

A SCHEMATIC REPRESENTATION:

Freshly extracted human mandibular first and second molars were collected and stored according to occupational safety and health (OSHA) regulation

FURCAL AREA OF CROSS SECTION ABOUT 1mm THICKNESS WAS PREPARED USING A DIAMOND DISC

GROUP 1: BIODENTINE (60 SAMPLES)

- GROUP IA: 20 samples IMMERSED IN 3.5% SODIUM HYPOCHLO-RITE FOR 30 MINUTES
- GROUP IB: 20 samples IMMERSED IN NORMAL SALINE FOR 30 MINUTES
- GROUP IC: 20 samples in Control group were not subjected to any immersion (no irrigants)

GROUP 2: ENDOSEQUENCE ROOT REPAIR MATERIAL (60 SAMPLES)

- GROUP II A: 20 samples IMMERSED IN 3.5% SODIUM HYPOCHL-ORITE FOR 30 MINUTES
- GROUP II B: 20 samples IMMERSED IN NORMAL SALINE FOR 30 MINUTES
- GROUP II C: 20 samples in Control group were not subjected to any immersion (no irrigants)

All the specimens were allowed to set for 48 hours at 37^0 C with 100% humidity in an incubator

All the specimens were subjected to PUSH- OUT bond strength analysis using "UNIVERSAL TESTING MACHINE"

All the specimens were subjected to "STEROMICROSCOPIC EXAMINATION" to evaluate the NATURE OF BOND FAILURE

Randomly selected samples were analyzed under "SCANNING ELECTRON MICROSCOPE" to evaluate the MORPHOLOGICAL CHANGES

APPROPRIATE STATISTICAL ANALYSIS WAS DONE

SAMPLE PREPARATION

Figure 1: 120 mandibular molars were selected for study.

Figure 2. Total 120 samples after furcal perforation.

Figure 3: Perforation repair made using Biodentine according to manufacturers instruction.

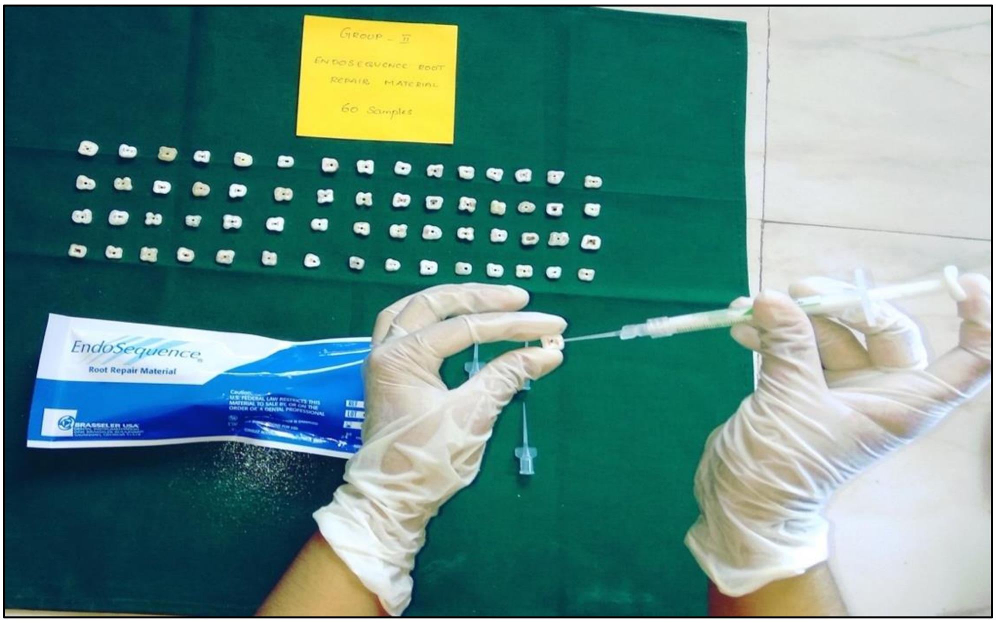


Figure 4: Perforation repair made using premixed ERRM syringe material.

Figure 5: Specimen immersion in 3.5% Sodium Hypochlorite, saline and no immersion (irrigants)in the control groups.

Figure 6: Incubation of samples for 48 hours at 37^0 C.

EQUIPMENTS USED

Figure 7: Jig and Plunger

Figure 8: Universal testing machine

Figure 9: Push – Out bond strength analysis

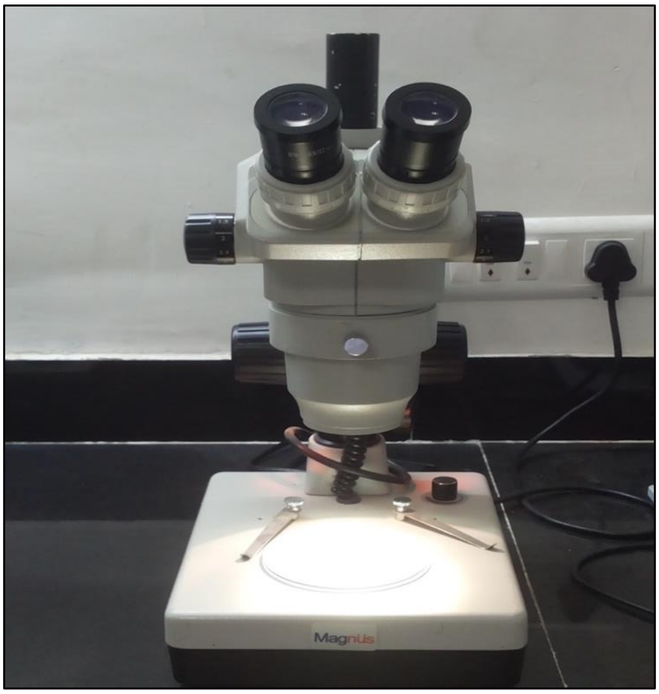


Figure 10: Stereomicroscope

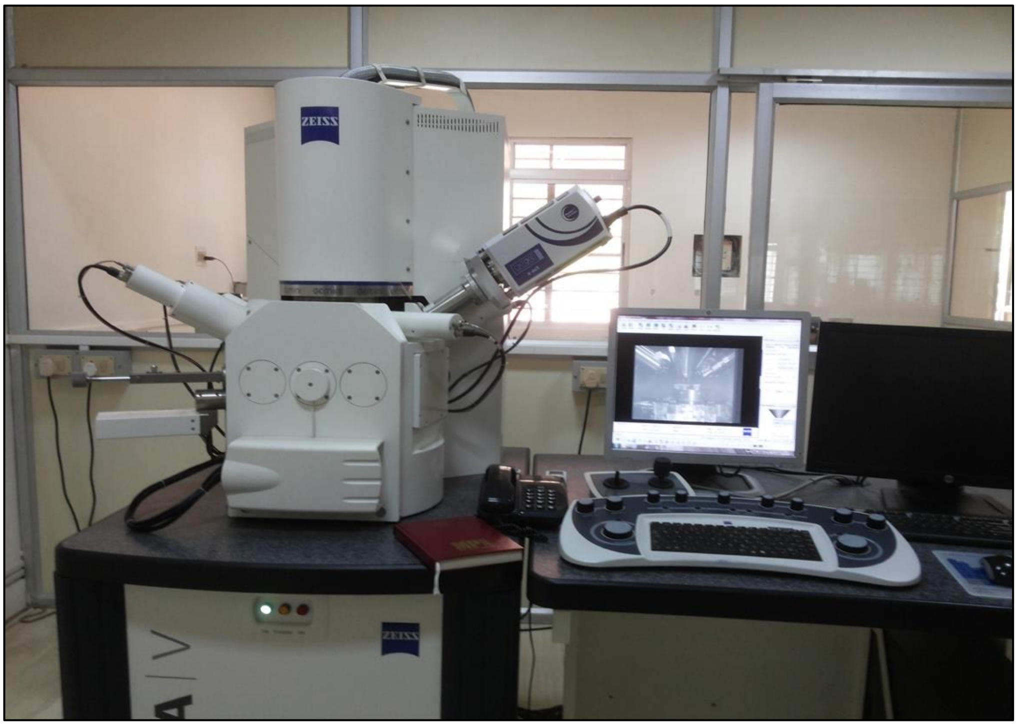


Figure 11: Scanning Electron Microscope

RESULTS

RESULTS

Sample no.	BD in NaCOl	BD in saline	BD without irrigants	ERRM in NaCOl	ERRM in saline	ERRM without irrigants
1	31.353	13.253	8.27	6.936	27.951	9.841
2	15.192	12.645	24.792	10.457	11.542	7.777
3	20.779	20.797	17.135	22.857	14.218	6.682
4	29.283	19.09	5.223	22.249	6.077	7.166
5	19.568	17.393	6.561	9.369	13.855	4.618
6	48.24	13.499	10.325	35.139	10.688	6.44
7	4.375	8.142	8.383	14.843	22.479	7.166
8	27.582	15.078	10.332	8.142	6.319	4.618
9	39.979	2.923	7.166	19.826	10.325	6.44
10	30.016	25.653	19.568	10.34	16.53	7.777
11	25.761	3.895	23.575	10.82	28.194	4.012
12	17.498	19.453	8.873	35.63	16.161	20.537
13	6.803	6.563	6.561	7.416	13.243	29.283
14	12.631	9.859	12.153	29.057	7.777	17.014
15	9.23	2.188	10.81	6.69	17.861	4.497
16	6.682	3.041	18.588	4.983	7.174	3.643
17	10.931	5.229	11.905	14.225	10.506	3.159
18	5.586	8.633	18.11	20.552	18.3	8.994
19	7.045	44.626	19.931	66.639	36.335	3.522
20	7.414	8.27	8.02	28.822	12.874	4.981

Table 1: Shows Push-out bond strength value in N/mm^2 of various bioceramic materials after treating the surface with NaOCl and Saline

PUSH – OUT BOND STRENGTH

Figure 12: Cohesive failure

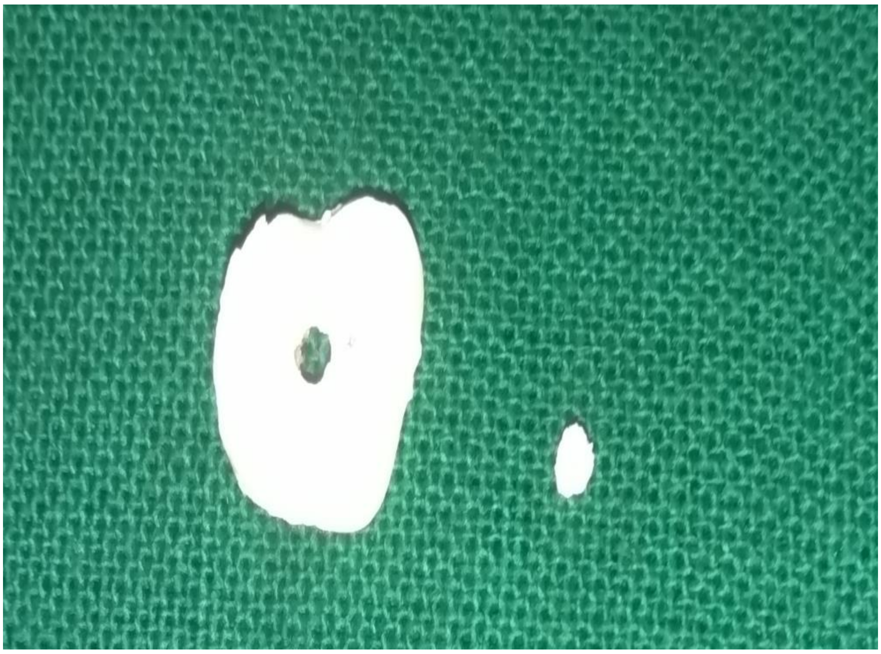


Figure 13: Mixed failure

STEREOMICROSCOPIC EVALUATION FOR NATURE OF BOND FAILURE ANALYSIS

Figure 14: Biodentine immersed in NaOCl - Cohesive failure

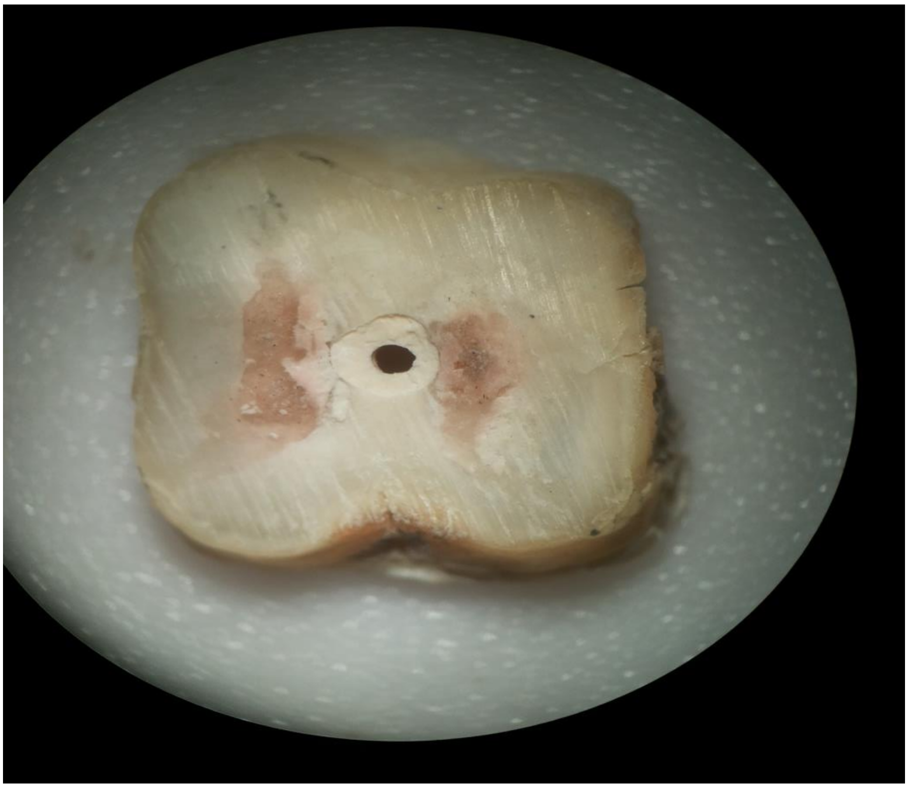


Figure 15: Biodentine immersed in saline - Cohesive failure

Figure 16: ERRM immersed in NaOCl - Cohesive failure

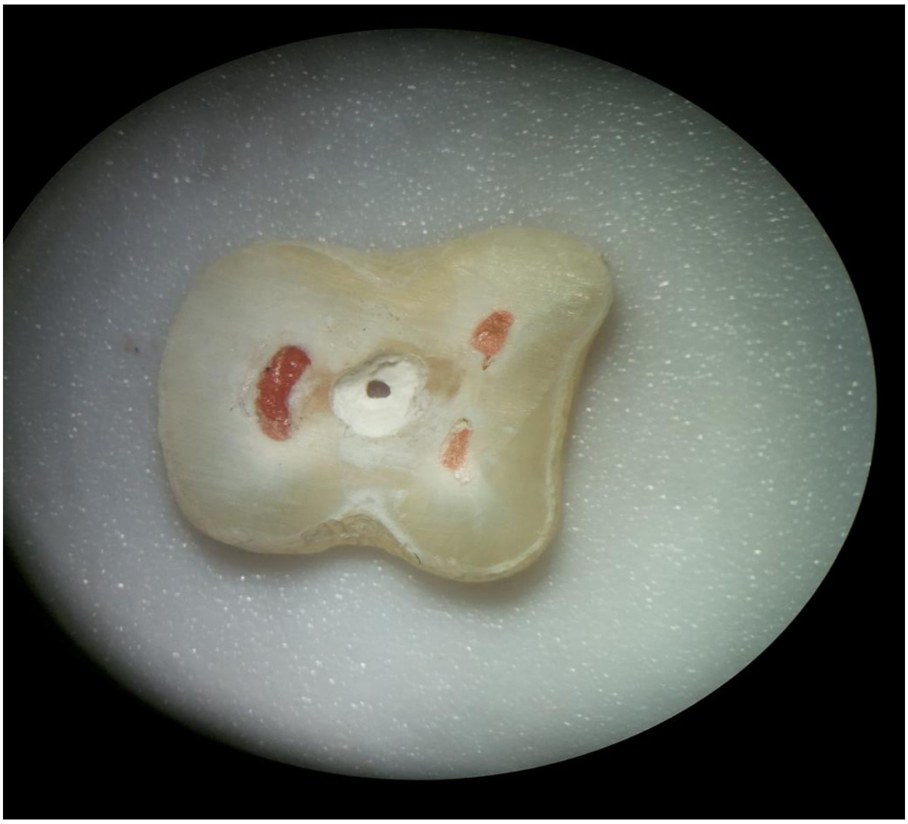


Figure 17: ERRM immersed in Saline- Cohesive failure

Figure 18: Biodentine in control group - Mixed failure

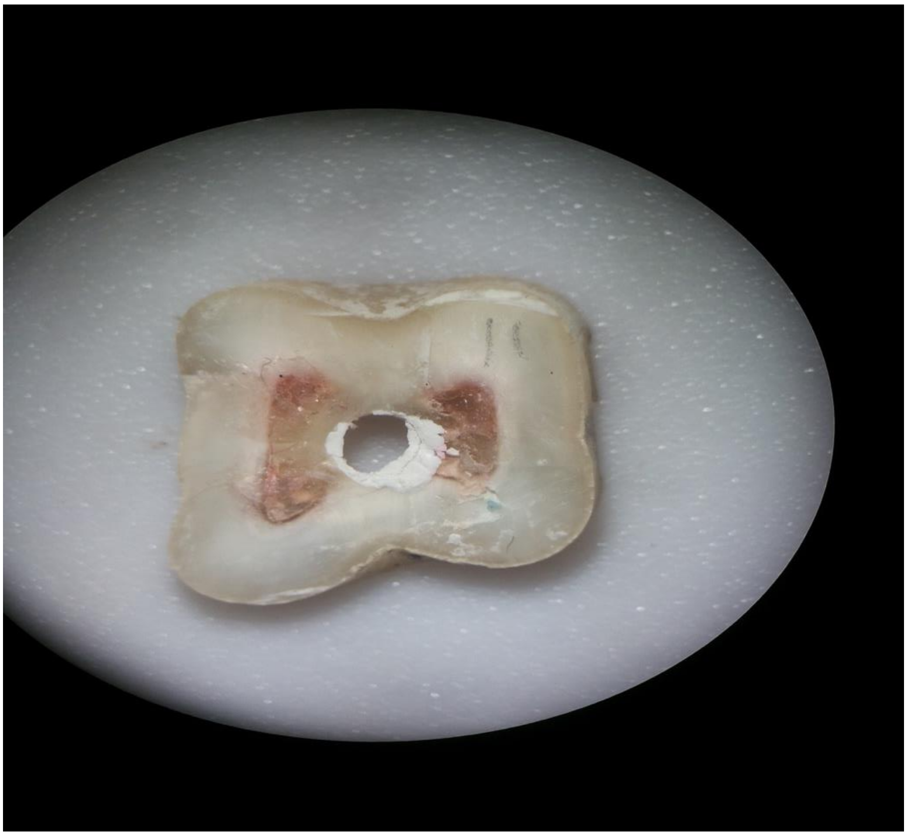


Figure 19: ERRM in control group - Mixed failure

SCANNING ELECTRON MICROSCOPIC EVALUATION

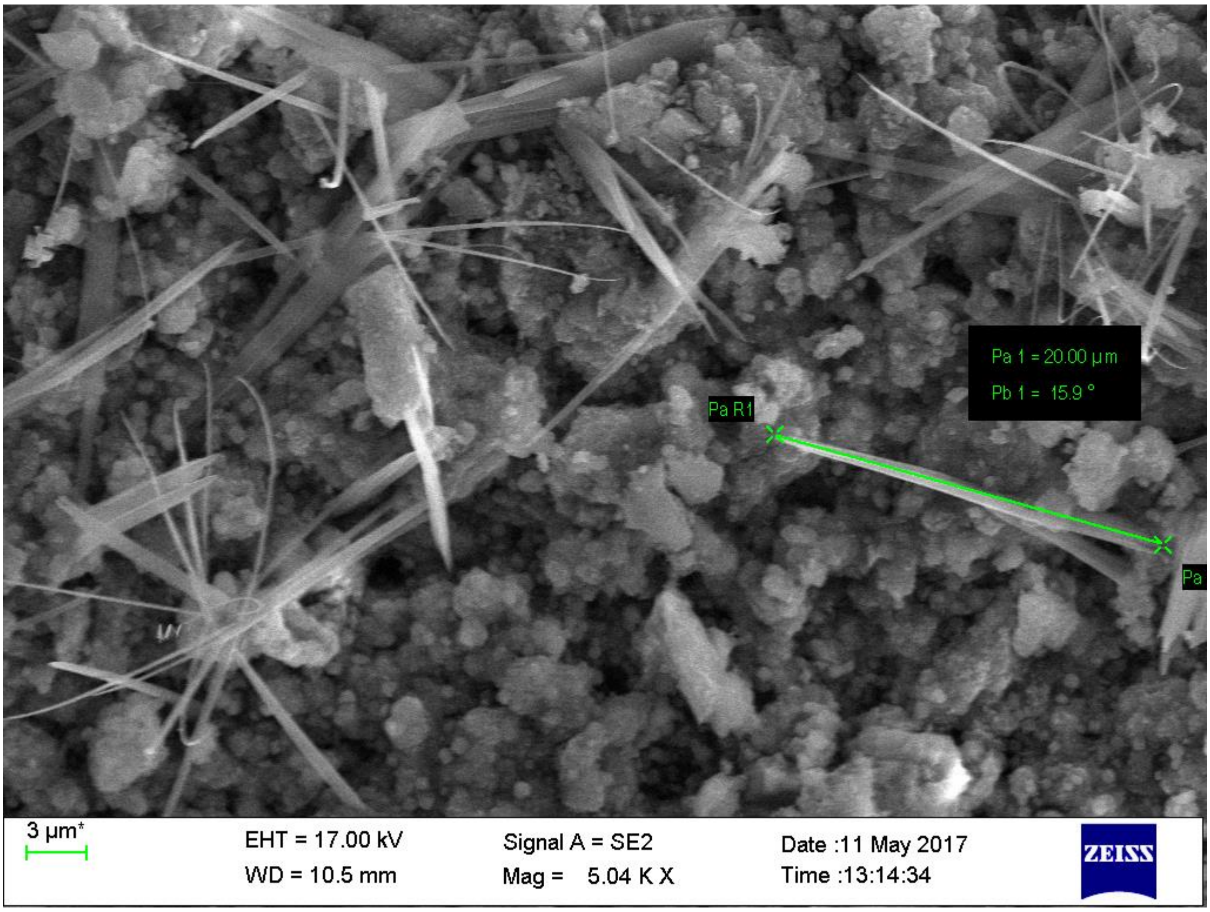


Figure 20: Biodentine immersed in NaOCl group – Formation of "Needle- like" crystals seen

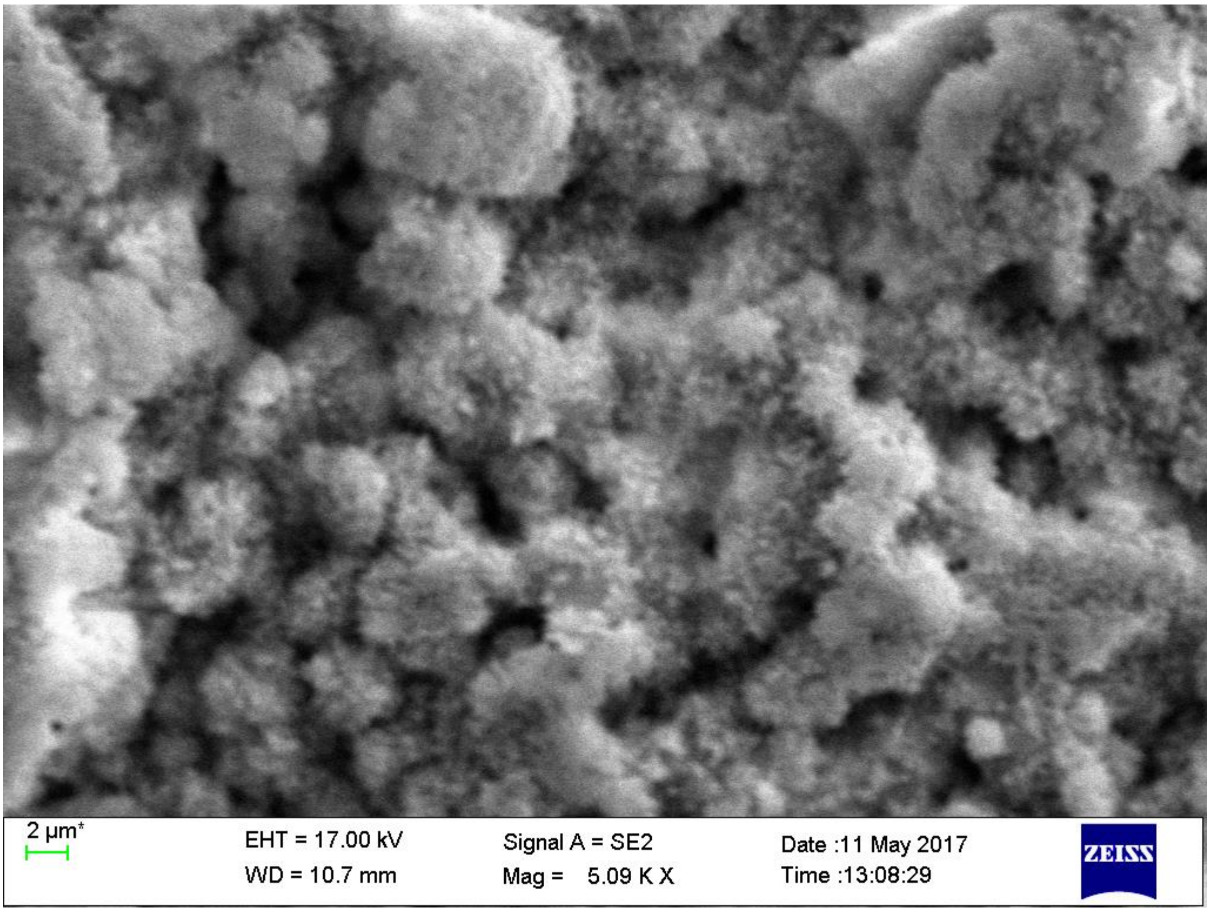


Figure 21: Biodentine immersed in saline group – “Needle – like crystals completely lost”

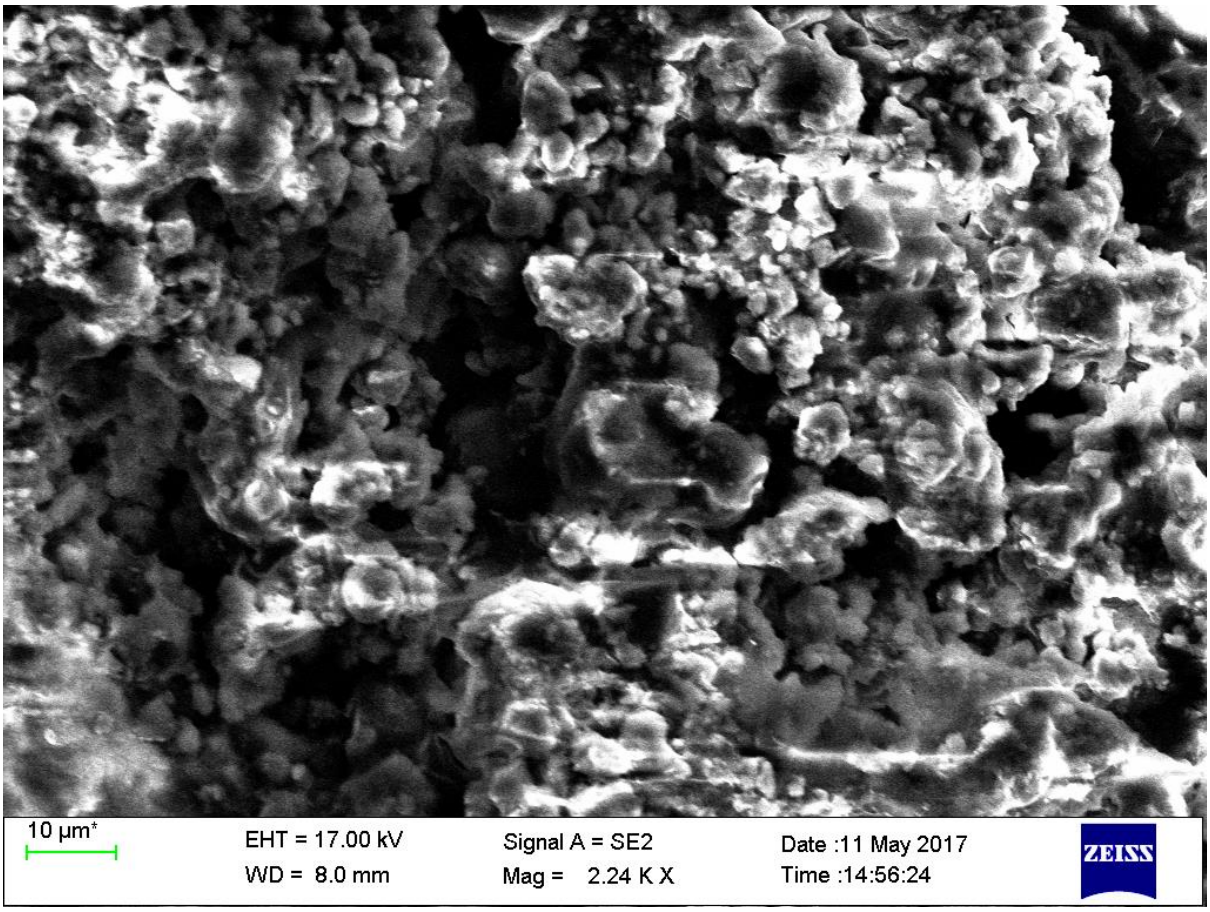


Figure 22: Biodentine in control group – “Irregular surface”

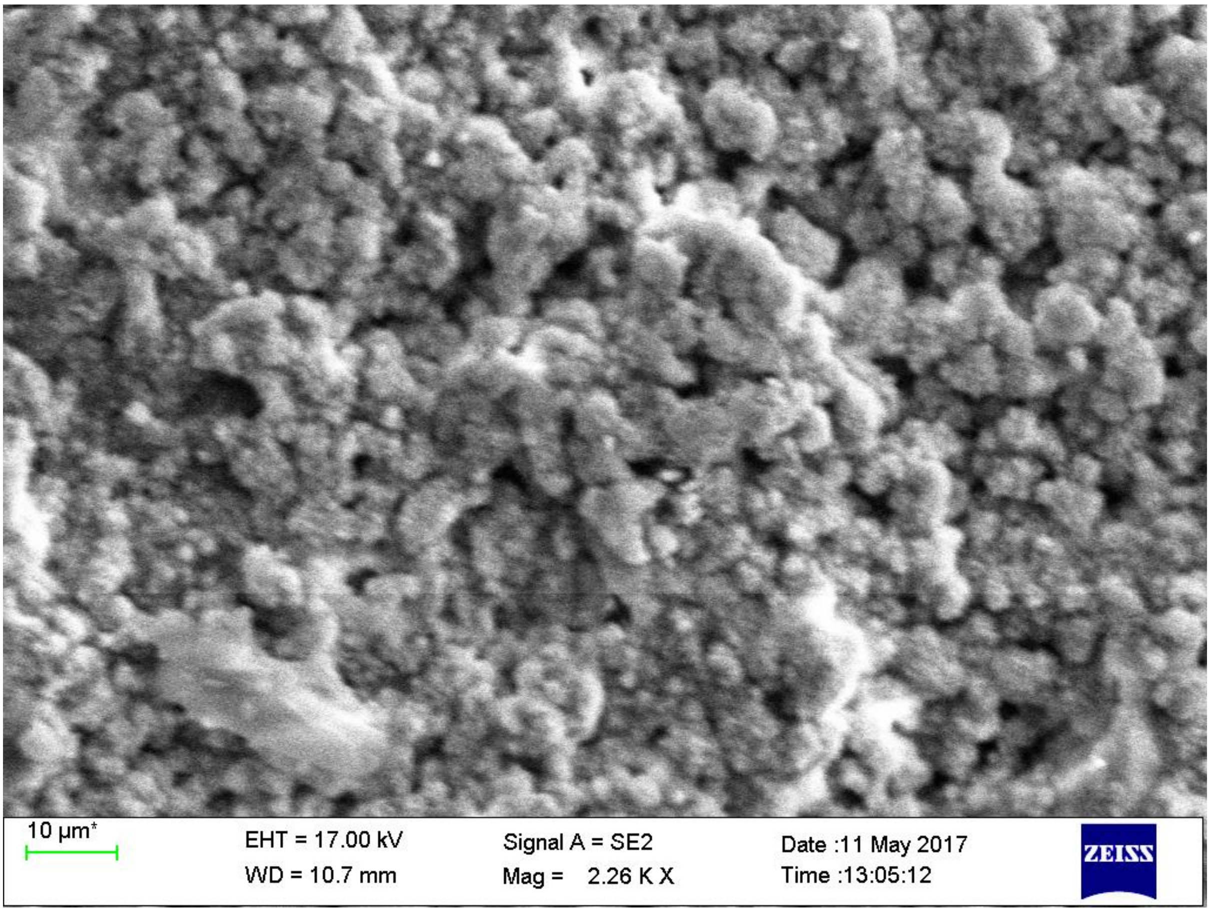


Figure 23: ERRM immersed in NaOCl group – “Spherical aggregates”

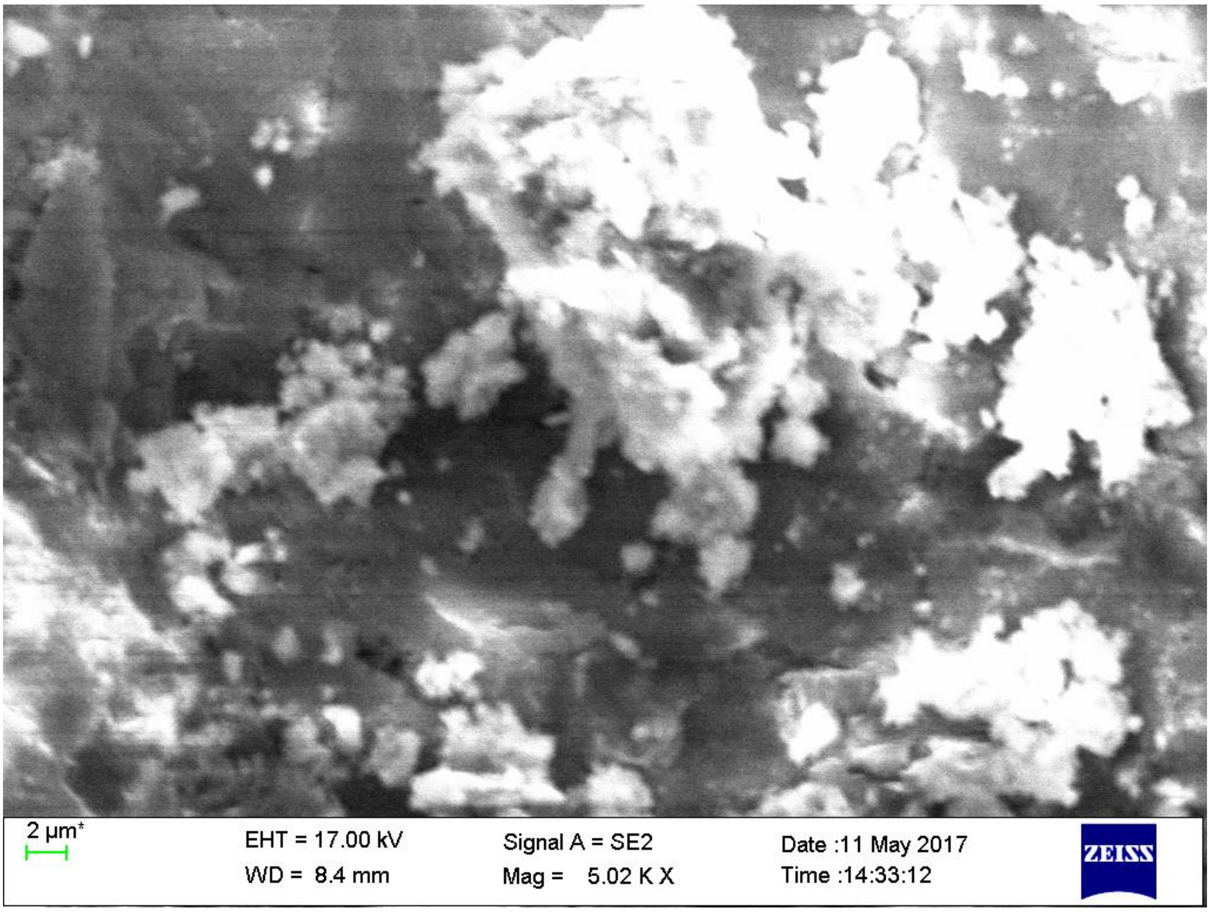


Figure 24: ERRM immersed in saline group - “Globular Particles”

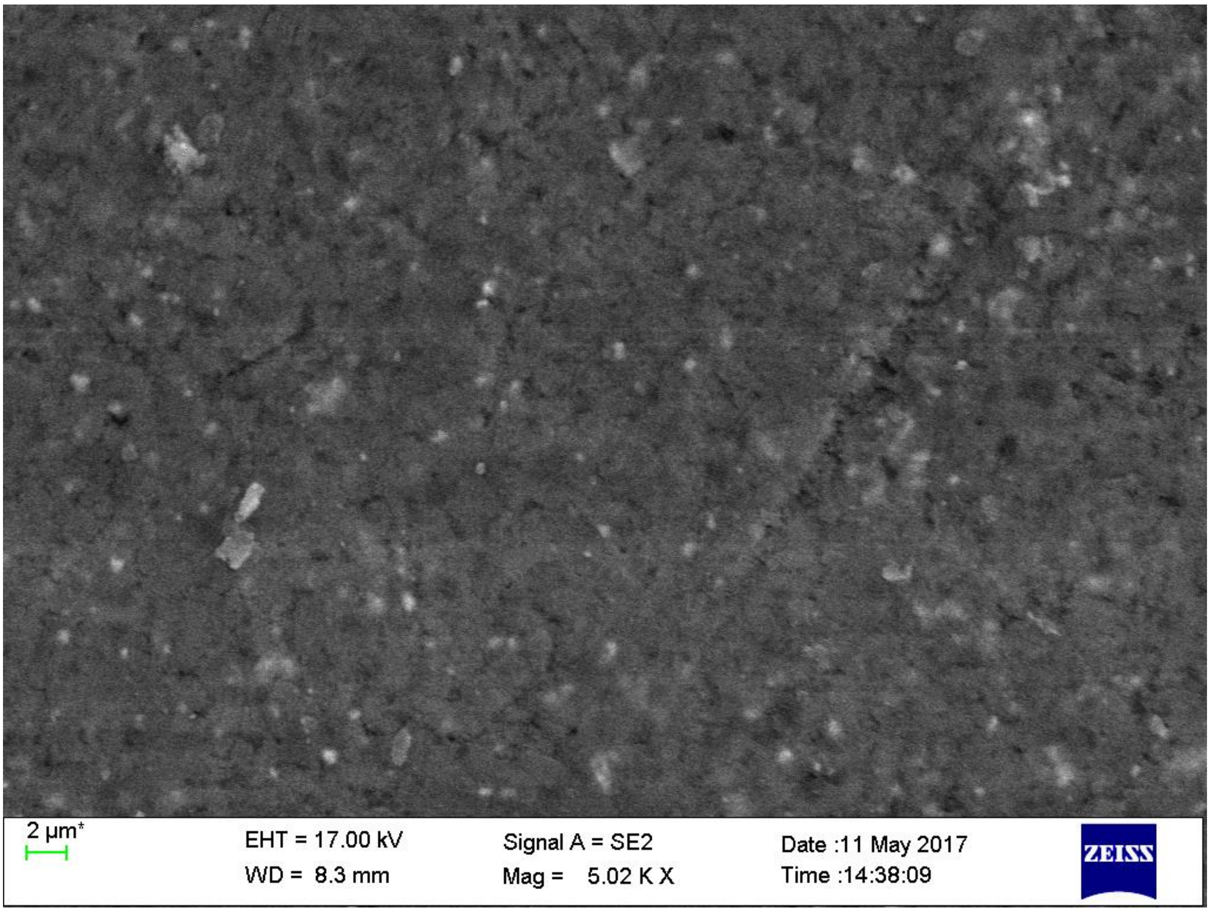


Figure 25: ERRM in contol group – “Lacks apatite-like layer”

STATISTICAL ANALYSIS

The collected data was subjected to statistical analysis using the statistical software SPSS 16 (SPSS, Chicago, IL, USA). The data was assessed for normality by Shapiro wilks test was employed to assess normality. Based on the distribution of data, the appropriate statistical test was used. Data was found to be in non - normal distribution. The differences between groups were analyzed by Kruskal wallis test and Mann whitney U test. The nature of bond failure analyzed using Chi-square test and graphs were plotted respectively.

Groups								Kruskal-Wall is Test	
	N	Minimum	Maximum	Mean	Std. Deviation	(Median)	Interquartile Range	Mean Rank	p value
Biodentine in sodium hypochlorite (Group I A)	20	4.3	48.2	18.7	12.5	16.3	21.7	72.4	
Biodentine in saline (Group I B)	20	2.1	44.6	13.0	10.0	11.2	13.1	54.8	
Biodentine without any irigants (Group I C)	20	5.2	24.7	12.8	6.0	10.5	10.3	60.2	0.002
ERRM in sodium hypochlorite (Group II A)	20	4.9	66.6	19.2	14.7	14.5	18.8	73.5	
ERRM in saline (Group II B)	20	6.0	36.3	15.4	8.0	13.5	7.8	68.9	
ERRM with out any irrigants (Group II C)	20	3.1	29.2	8.4	6.5	6.5	4.1	32.9	

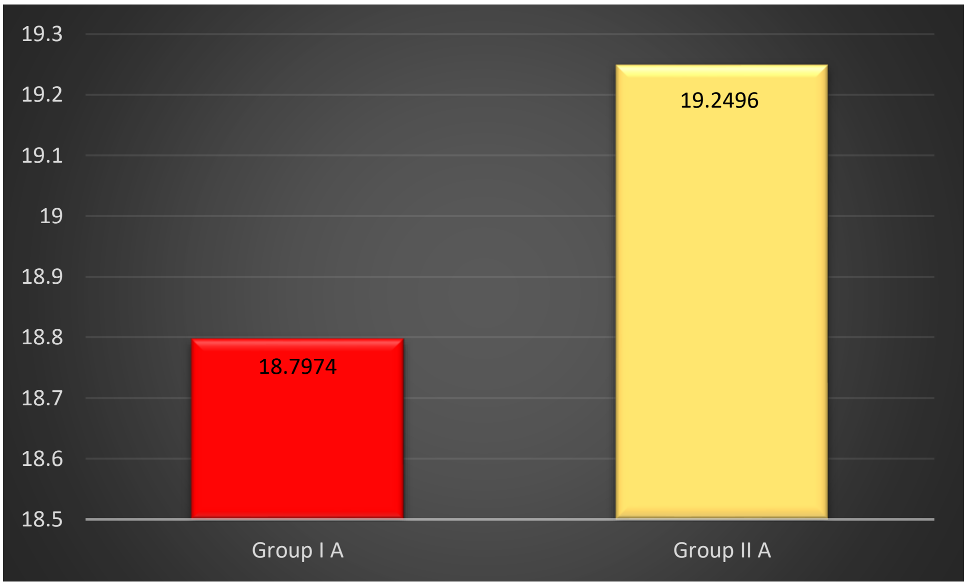
Table 2: The mean Push-out bond strength value in N/mm^2 of various bioceramic materials After treating the surface with NaOCl, Saline and without any irrigants.

The p value is kept at <0.05. Kruskal wallis test analysis was done to evaluate the non parametric mean score to find influence of sodium hypochlorite, saline and without any irrigant (control) on biodentine and ERRM was analyzed. There is a significant difference present and the p value is 0.002 between biodentine (group IA, group IB, group IC) and ERRM (group IIA, group IIB, group IIC) groups respectively.

INTERGROUP COMPARISION

Groups	N	Minimum	Maximum	Mean	Std. Deviation	Mann whitney U test (Median)	Interquartile Range	Mean Rank	p value
Biodentine in sodium hypochlorite (Group I A)	20	4.3	48.2	18.7	12.5	16.3	21.7	20.40	
ERRM in sodium hypochlorite (Group II A)	20	4.9	66.6	19.2	14.7	14.5	18.8	20.60	0.957

Table 3: Mean Push-out bond strength value of Group IA and Group IIA
The p value is 0.957 which is statistically insignificant.



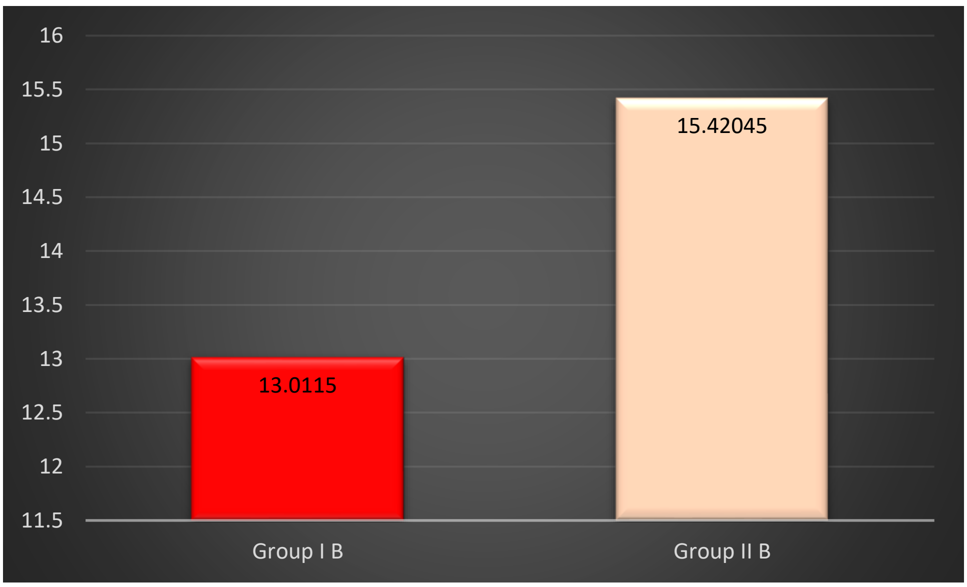
Graph 2: Shows Push-out bond strength value in N/mm^2 of Group IA and Group IIA

The mean push – out bond strength value of group I A is 18.797 and group IIA is 19.2496
The graph shows group IIA is higher in bond strength than group IA

Groups	N	Minimum	Maximum	Mean	Std. Deviation	(Median)	Interquartile Range	Mann whitney U test	
								Mean Rank	p value
Biodentine in saline (Group I B)	20	2.1	44.6	13.0	10.0	11.2	13.1	18.35	0.245
ERRM in saline (Group II B)	20	6.0	36.3	15.4	8.0	13.5	7.8	22.65	

Table 4: Mean Push-out bond strength value of Group IB and Group IIB

The p value is 0.245 which is statistically insignificant.



Graph 3: Shows Push-out bond strength value in N/mm^2 of Group IB and Group IIB

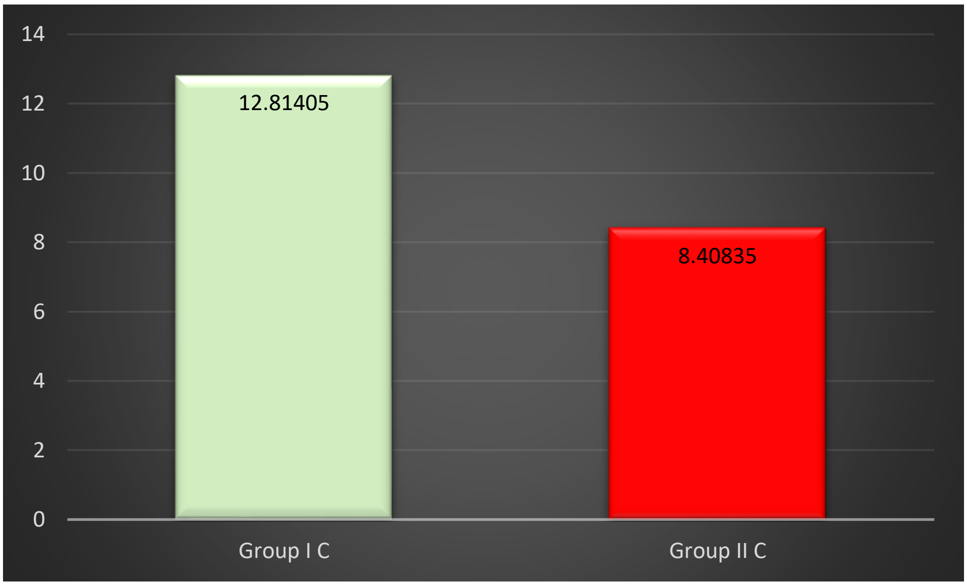
The mean push – out bond strength value of group I B is 13.01 and group II B is 15.42

The graph shows group II B is higher in bond strength than group I B

Groups	N	Minimum	Maximum	Mean	Std. Deviation	(Median)	Interquartile Range	Mann whitney U test	
								Mean Rank	p value
Biodentine without any irrigants (Group I C)	20	5.2	24.7	12.8	6.0	10.5	10.3	26.15	0.002
ERRM with out any irrigants (Group II C)	20	3.1	29.2	8.4	6.5	6.5	4.1	14.85	

Table 5: Mean Push-out bond strength value of Group IC and Group IIC

The p value is 0.002 which is statistically significant.



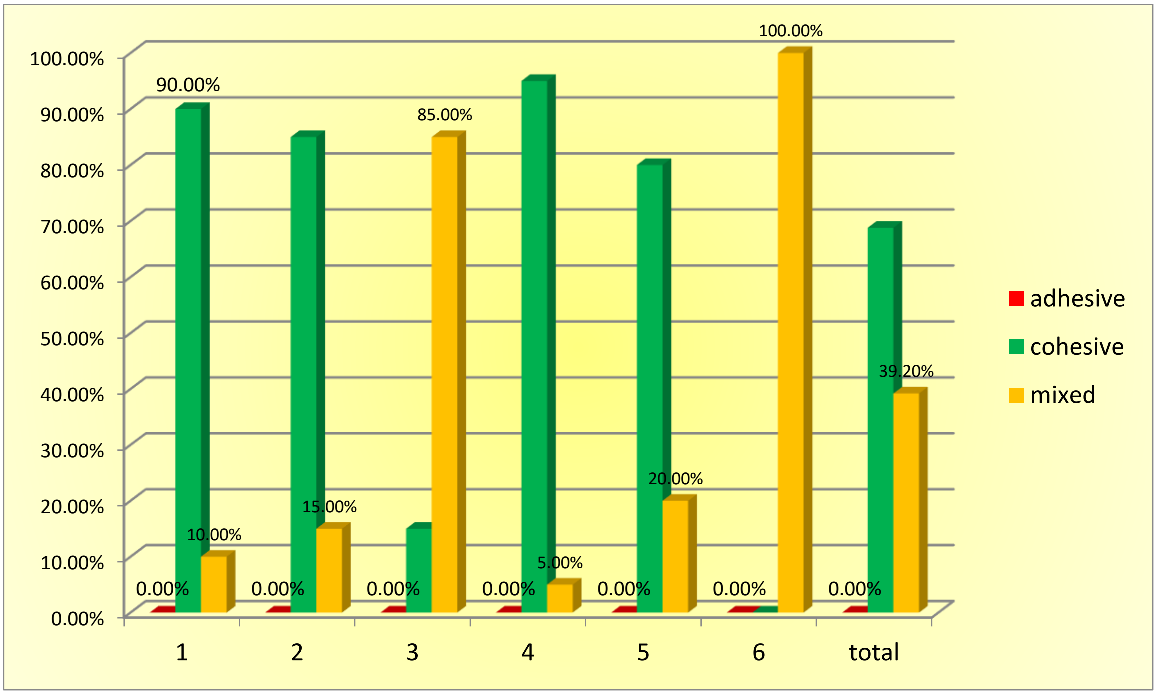
Graph 4: Shows Push-out bond strength value in N/mm^2 of Group IC and Group IIC

The mean push – out bond strength value of group I C is 12.814 and group II C is 8.408

The graph shows group I C is higher in bond strength than group II C

Groups	Adhesive	Cohesive	Mixed	Chi square test	
				Chi squared value	P value
Biodentine in sodium hypochlorite (Group I A)	0 .0%	18 90.0%	2 10.0%	95.216	0.000
Biodentine in saline (Group I B)	0 .0%	17 85.0%	3 15.0%		
Biodentine without any irrigants (Group I C)	0 0%	3 15%	17 85.0%		
ERRM in sodium hypochlorite (Group II A)	0 .0%	19 95.0%	1 5.0%		
ERRM in saline (Group II B)	0 .0%	16 80.0%	4 20.0%		
ERRM without any irrigants (Group II C)	0 .0%	0 .0%	20 100.0%		

Table 6: Shows the percentage of bond failure in each subgroup. ERRM shows a low bond failure rate compared to biodentine with a high statistical significance of p value - 0.000



Graph 5: The percentage of bond failure in each subgroup. None of the samples had undergone adhesive mode of failure. ERRM shows much lower bond strength of (100%) mixed mode of failure.

1 – Group I A 90% cohesive mode of failure.

2 - Group I B 85% cohesive mode of failure.

3 – Group I C 85% mixed mode of failure.

4 - Group II A 95% cohesive mode of failure.

5 - Group II B 80% cohesive mode of failure.

6 - Group II C 100% mixed mode of failure.

PUSH OUT BOND STRENGTH:

The mean push-out strength values and standard deviation in each groups are presented in Table 2. Higher bond strength was observed in ERRM sodium hypochlorite-treated group (Group II A). In saline-treated group the bond strength of ERRM samples (Group IIB) is significantly higher than Biodentine samples (Group I B). In control group, the lowest bond strength was observed in ERRM samples without any irrigants (Group II C) in comparison with Biodentine samples without any irrigants (Group IC).

However, NaOCl significantly increased the push out bond strength of ERRM (Group II A) and Biodentine (Group I A) samples. Saline had negative influence on biodentine and significantly reduced the bond strength. In control groups both ERRM and Biodentine samples showed significant reduction in bond strength in contrast with groups treated with irrigants.

MODE OF BOND FAILURE:

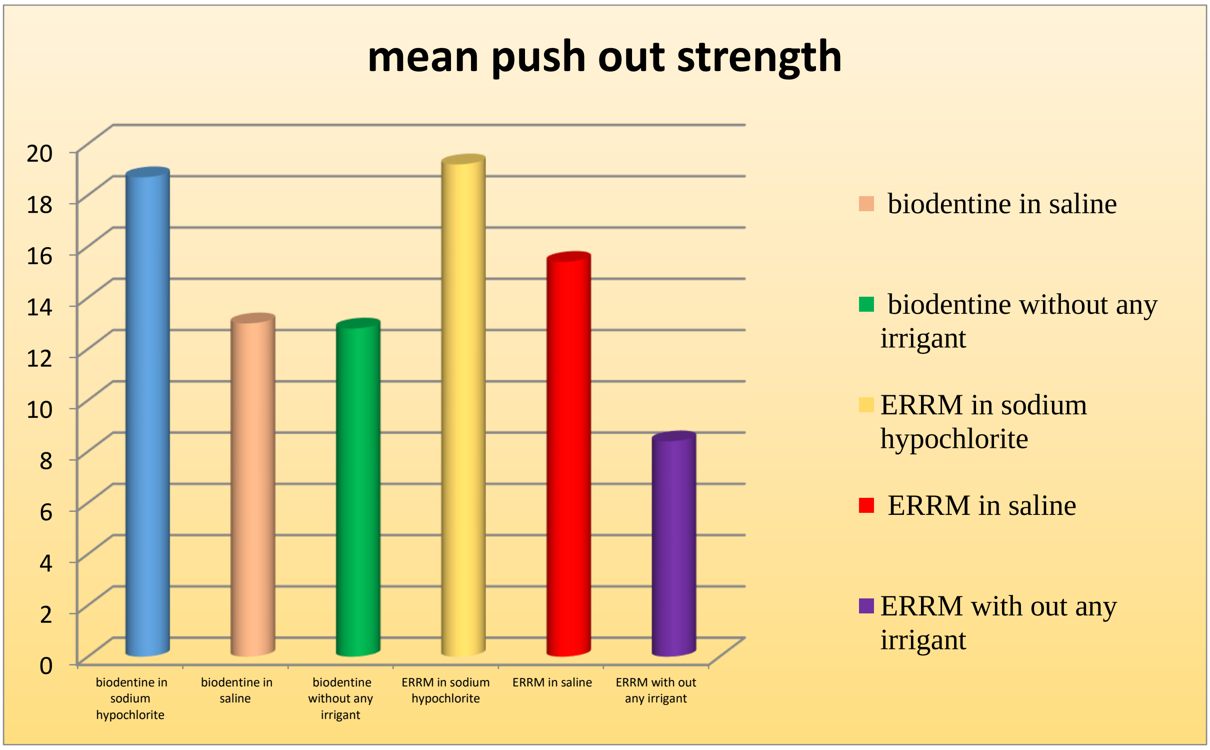
The nature of bond failure was examined under stereomicroscope. All the samples were subjected to stereomicroscopic evaluation and images of the specimens were recorded. The nature of bond failure was predominantly cohesive and mixed type. None of the specimens in our study showed an adhesive mode of failure. The majority of the specimens immersed in irrigants exhibit cohesive mode of failure (Figure 14,15,16 and 17). But, control groups (without immersion in any irrigants) showed predominantly mixed mode of failure (Figure 18 and 19) in both biodentine and ERRM samples.

SCANNING ELECTRON MICROSCOPIC EVALUATION:

The morphological characteristic changes were observed under scanning electron microscope. On examination, it revealed that the microstructure of biodentine samples when contacted with NaOCl, showed needle – like crystal deposition on the surface of biodentine samples (figure 20). ERRM samples when contacted with NaOCl showed smooth spherical acicular particles forming apatite like layer (figure 23). In saline treated group, biodentine samples lost their apatite like – crystal deposition with irregular spherical structures (figure 21). ERRM samples immersed with saline showed aggregates composed of individual and fused globular particles (figure 24). In control group, biodentine samples showed irregular spherical structure with voids (figure 22) and ERRM samples lacks apatite-like layer with very sparse spherical particles (figure 25).

SUMMATIVE CONCLUSION

The bar diagram shows the mean push – out bond strength values of group I A is 18.7, Group I B is 13.01, Group I C is 12.8, Group II A is 19.2, Group II B is 15.4, Group IIC is 8.4.



Graph 1: Shows Push-out bond strength value in N/mm^2 of various bioceramic materials after treating the surface with NaOCl and Saline.

According to statistical analysis, ERRM immersed in sodium hypochlorite showed higher push – out bond strength when compared with all the other groups. In contrast, ERRM samples in the control group (i.e. without any immersion) showed much lower resistance against dislodgement forces than all other groups. Eventually, samples immersed in sodium hypochlorite (Group IA, Group IIA) showed higher bond strength when compared with saline (Group IB, Group IIB) treated and control groups (Group IC, Group IIC).

DISCUSSION

DISCUSSION

An ideal furcal perforation repair material should adhere well and resist against dislodging forces in both static conditions as well as during function. [39,40] This in-vitro study was performed to evaluate the compressive stress of two different bioceramic materials. The push-out bond strength analysis is an efficient and reliable methodology that can be compared with the clinical situation, in which the test materials are analyzed with natural canal space and tubule arrangement. [40] While conducting this study to evaluate the push-out bond strength, the test load was applied perpendicular. This helps in simulate the clinical stress. [41] Therefore, the push-out bond strength examination aids in accurate specimen standardization. [41]

However, certain variables which affects the push – out test, such as orientation of specimens, variations in root canal diameter and plunger sizes. [39] To overcome these limitations, in this study uniform root sections of 1mm thickness were prepared. Furcal perforations were made using standardized round burs to produce 1.4mm diameter of furcal perforation. Furcal perforation repair was performed as per the manufacturer's instructions. Biodentine liquid from a single-dose container was emptied into a powder-containing capsule and mixed for 30 seconds at 4,000– 4,200 rpm.

Endosequence Root Repair Material, which is a premixed syringe with calibrated intracanal tips was used to repair the perforation site without any mechanical manipulation. The plunger used in the present study was 1.2mm diameter, selected which corresponds to the canal diameter. [40]

THE BIODENTINE SAMPLES IMMERSED IN NaOCl

PUSH – OUT BOND STRENGTH EXAMINATION:

The biodentine samples immersed in NaOCl showed a mean value of 18.797 in comparison with ERRM samples immersed in NaOCl, which showed a mean value of 19.249. This is statistically not significant in numerical values. Though the statistical analysis showed statistically insignificant values the biodentine samples immersed in the NaOCl showed high bond strength. The first possible reason might be that; Sodium hypochlorite has an alkaline pH of 9.0-10.5. According to Uyanik et al, The high pH environment of NaOCl has a positive influence on enhancing the numerous physical and chemical properties of calcium silicate based restorative material. [26] The second possible reason might be that, the biodentine micromechanically adheres to the dentinal tubules because of its alkaline effect during the setting reaction. The high pH of biodentine results in organic tissue dissolution via the dentinal tubules. The alkaline nature of biodentine on its boundary area of contact with the hard tooth substance creates a way. This exposed opening of dentin canaliculi aids the dentin substitute mass to enter creating a stable anchor. The innumerable microscopic cones are formed by biodentine which aids in production of a stable anchorage with enhanced sealing effect. [42,43] Thirdly, When Biodentine gets exposed to NaOCl, it enhances the size and number of calcium hydroxide crystals and also calcium is released. Thus, building up of calcium hydroxide, enhances the pH of biodentine results in greater sealing ability of the material. [44] Finally, the biodentine has the ability to biomineralize, [42,45] This biomeneralization is via formation of tags. They formed “tag-like” structure because of calcium and silicon ion uptake into the dentinal tubules. [46,2] So, these are the possible reasons that the biodentine samples immersed in sodium hypochlorite groups showed high bond strength.

SCANNING ELECTRON MICROSCOPIC EVALUATION:

The results of SEM observation of biodentine samples immersed in NaOCl group revealed needle-like crystals with an apatitic appearance. [46,47] The needle – like crystal growth aids in enhanced adhesion to root dentine. [9] This might be the possible reason that the biodentine samples treated with NaOCl, showed high resistance against dislodgement forces. This resulted in enhanced adhesion between the biodentine and dentinal wall interface.

STEREOMICROSCOPIC EXAMINATION TO EVALUATE MODE OF BOND FAILURE:

None of the biodentine samples immersed in NaOCl group had undergone adhesive mode of failure. This is in agreement with Sara A Alsubait et al (2017). [8] Instead, majority of the samples about 90% had predominantly cohesive mode of failure. The biodentine samples formed tag-like structures with in the dentinal tubules, forming a micromechanical anchor, that might cause a cohesive mode of bond failure. This result is in agreement with earlier studies that Biodentine to tooth interface failures were predominantly cohesive in nature. [13,2]

THE BIODENTINE SAMPLES IMMERSED IN SALINE

PUSH – OUT BOND STRENGTH EXAMINATION:

The mean (13.011) push – out bond strength of biodentine samples immersed in saline is comparatively lesser than that of ERRM samples immersed in saline with a mean of (15.420).

The biodentine samples immersed in saline group showed reduced resistance against dislodgment forces.The possible reason might be that, the biodentine has a setting time of 9-12 minutes. As per per manufacturer's instruction during initial setting time of biodentine it should be avoided from exposure to water. In this study biodentine samples were immersed in saline after 10min of furcal perforation repair that is, before its total setting time of 12 minutes. This might hamper the setting reaction resulting in lesser values of bond strength. [38] Thus, saline exposure during its earlier setting time had a negative influence on biodentine. [48,38] This result obtained is in agreement with Vandana Gade et al.

SCANNING ELECTRON MICROSCOPIC EVALUATION:

On SEM evaluation the biodentine samples immersed in saline showed a loss of its classic needle-like structure. This altered surface of the sample appears spherical shaped with irregular borders and the needle-like structure completely lost. This might be due to the negative influence of saline over biodentine on its initial setting time, which alters its surface characteristic resulting in reduced bond strength.

STEREOMICROSCOPIC EXAMINATION TO EVALUATE MODE OF BOND FAILURE:

None of the biodentine samples immersed in saline had undergone adhesive mode of failure. This is in agreement with Sara A Alsubait et al (2017). [8] The biodentine samples immersed in saline showed predominantly (about 85%) cohesive mode of failure. This may be explained by the smaller particle size and uniform components that might have a role in better interlocking of biodentine with the dentinal tubules, which finally causes cohesive failure inside the cement.

THE BIODENTINE SAMPLES IN CONTROL GROUP WITHOUT ANY IMMERSION

PUSH – OUT BOND STRENGTH EXAMINATION:

On over all comparison, the control groups of both biodentine and ERRM showed significant reduction in bond strength, when compared to the sodium hypochlorite and saline treated groups. The mean (12.80) push-out bond strength of Biodentine samples in control group had statistically significant difference in comparison with ERRM control group. The possible reason might be that, the calcium silicate-based filling materials sets via hydration reaction. [49] When used for perforation repair, the hydraulic cements adherence with the surrounding dentin is mandatory. Thus, during the setting reaction water availability for calcium-silicate based material (biodentine) plays a essential role in determining the final strength of the completely set material. [50] Thus, biodentine in control group showed reduced push – out bond strength.

SCANNING ELECTRON MICROSCOPIC EVALUATION:

On SEM evaluation biodentine samples in the control group showed morphological alterations. The samples exhibited irregular surfaces without any defined shape of the particles. This morphologic alteration might be because of insufficient hydration during the setting reaction of biodentine. Thus, this results in reduced resistance against dislodgment forces.

STEREOMICROSCOPIC EXAMINATION TO EVALUATE MODE OF BOND FAILURE:

The biodentine samples in control group showed predominantly mixed mode of failure (about 85%). This proves its poor adhesion to the dentine interface as well as reduced resistance against dislodgment forces. The samples in the control group of biodentine were not subjected to any immersion in irrigants. Since water available during the setting reaction of calcium-silicate based material (biodentine) plays a major role in determining the final strength of the material. [50] Besides, the samples in control group of biodentine were wrapped in a wet cotton pellet and allowed to set for 48 hours. No extra moisture was available for the complete setting reaction of the material. This, resulted in a mixed mode of failure.

THE ERRM SAMPLES IMMERSED IN NaOCl

PUSH – OUT BOND STRENGTH EXAMINATION:

The ERRM samples immersed in NaOCl showed a mean value of 19.249 presenting higher push-out bond strength when compared with all the other groups. The possible reason might be that, ERRM is a premixed cement that sets in the presence of moisture. The Sodium hypochlorite immersion improves the physical property of ERRM. The enhanced moisture during the setting of ERRM helps in greater the compressive strength of the material. [8] The nanosphere particles of the ERRM material which has the particle size of maximum diameter of 1×10^{-3} µm. This finer particle allows the ERRM to enter into the dentinal tubules. The moisture of the dentinal tubules is maintained by dentinal fluid. This creates a micromechanical bond upon setting. This resulted in higher bond strength.

SCANNING ELECTRON MICROSCOPIC EVALUATION:

On SEM evaluation, the ERRM samples immersed in NaOCl showed uniformly arranged spherical shaped crystals presenting hydroxyapatite or apatite – like layer. This increases the mechanical bond strength of ERRM with the dentinal tubules. This resulted in increased resistance against dislodgment forces.

In this study, Sodium hypochlorite exposure had a positive influence on both biodentine and ERRM groups.

STEREOMICROSCOPIC EXAMINATION TO EVALUATE MODE OF BOND FAILURE:

None of the ERRM samples immersed in NaOCl had undergone adhesive mode of failure. This result is in agreement with Sara A Alsubait et al (2017). [38] These ERRM samples had predominantly cohesive mode of failure (about 95%). The possible reason might be that, the ERRM material has nanosphere particles which allows the material to enter into the dentinal tubules creating a micromechanical bond with the dentine interface upon setting. This might be the cause for cohesive mode of failure.

THE ERRM SAMPLES IMMERSED IN SALINE

PUSH – OUT BOND STRENGTH EXAMINATION:

The ERRM samples immersed in saline showed higher bond strength after being exposed to saline than biodentine samples immersed in saline. The possible reason might be that, the slight expansion in the ERRM material on exposure saline had effectively enhanced the marginal adaptation and sealing ability. This slight expansion increases the adhesive property between the material and dentinal interface resulting in increased push – out bond strength. This result is in accordance with Walsh et al. [51]

SCANNING ELECTRON MICROSCOPIC EVALUATION:

On SEM evaluation, the ERRM samples immersed in saline group showed aggregate like structure which is composed of individual and fused globular hydroxyapatite particles, [52] which aids in better adherence with the dentinal walls resulting in high resistance against dislodgement forces.

STEREOMICROSCOPIC EXAMINATION TO EVALUATE MODE OF BOND FAILURE:

None of the ERRM samples immersed in saline group had undergone adhesive mode of failure. This result is in agreement with Sara A Alsubait et al (2017). [38] These samples they had predominantly cohesive mode of failure (about 80%). The possible reason might be that, ERRM samples immersed in saline group was completely covered by saline during its setting reaction. This aids in complete setting and adequate strength of the material. The cohesive bond failure can be explained by tubule penetration of finer nanosphere particles of ERRM syringe material.

THE ERRM SAMPLES IN CONTROL GROUP WITHOUT ANY IMMERSION

PUSH – OUT BOND STRENGTH EXAMINATION:

The mean (8.408) push-out bond strength of ERRM samples in the control group was much lower when compared with all the other groups. On comparing the biodentine control group with the ERRM control group, ERRM control group showed statistically significant reduction in bond strength. The possible reason might be that, in this study all the samples in the control groups were only covered with moist cotton pellet without any immersion in irrigants. According to manufacturer's instruction, the moisture present in the dentinal tubules is adequate and aids in the setting reaction of ERRM. But, it was observed that the material started to set only when water is completely covered. [17] So, additional moisture is required for the setting reaction of ERRM. But, the samples in the control group were not subjected to any additional moisture by immersion. Thus, resulting in inadequate setting as well as poor strength of the cement material producing much lower resistance against dislodgement forces and reduced bond strength.

SCANNING ELECTRON MICROSCOPIC EVALUATION:

On SEM evaluation the ERRM samples in the control group showed loss of hydroxyapatite like crystals. The surface showed very sparse apatite like crystals much reduced in numerical count. The absence of hydroxyapatite like layer on its surface may be inadequate water availability during its setting reaction. This reduces the mechanical bond strength of ERRM with the dentinal tubules. This resulted in reduced push – out bond strength.

STEREOMICROSCOPIC EXAMINATION TO EVALUATE MODE OF BOND FAILURE:

The ERRM samples in the control group showed higher percentage of (100%) mixed failure than biodentine (85%) in control group. During the in vitro study it was observed that ERRM samples started to set only when the material is completely covered by water which is in accordance with Lovato et al. [17] So, none of the ERRM samples immersed in irrigants (group IIA and group IIB) showed adhesive or mixed mode of failure. This proves its complete setting reaction as well as enhanced adherence with the dentinal interface. Thus, additional moisture too is needed for complete setting reaction of ERRM. As per the manufacturers recommendation the setting time of ERRM is about 4hrs but it took longer duration for complete setting of ERRM than the manufacturers instruction especially in the dry environment. This finding is in accordance with Charland et al. [53] This might be the possible reason that ERRM samples in control group (group II C) showed predominantly mixed mode of failure.

SUMMARY

SUMMARY

The present study was done to evaluate the effect of sodium hypochlorite on the push-out bond strength of Biodentine (BD) in comparison with Endosequence root repair material (ERRM) on furcal perforation. In this study, furcal perforation repair of 120 specimens were made, out of which 60 samples were repaired with biodentine and the remaining 60 samples were repaired using endosequence root repair material. The test materials were incrementally placed into the prepared furcal space of the dentin slices and condensed gently.

Subsequently, the samples were wrapped in wet gauze, placed in an incubator, and allowed to set for 10 minutes at 37^0C with 100% humidity. Immediately after incubation, the samples were divided into 6 subgroups according to the immersion, each subgroup contained 20 samples. In subgroup IA (n=20), perforation area was repaired with biodentine and immersed into 3.5% NaOCl. In subgroup IB (n = 20), perforation area was repaired with biodentine and immersed in saline solution. In subgroup IC (n = 20), perforation area was repaired with biodentine. No immersion (irrigants) was performed in the controls. In subgroup II A (n = 20), perforation area was repaired with ERRM and immersed into 3.5% NaOCl. In subgroup II B (n = 20), perforation area was repaired with ERRM and immersed in saline solution. In subgroup II C (n = 20), perforation area was repaired with ERRM. No immersion (irrigants) was performed in the controls. After 30 minutes of immersion on the respective test solutions, all samples were removed washed with distilled water. Then all the specimens were allowed to set for 48 hours at 37^0 C with 100% humidity using an incubator. In control group, a wet cotton pellet was placed over each specimen restored with repair material without any

irrigation and 48 hours allowed to set. All the samples were subjected to push-out bond strength analysis. The resistance against dislodgment forces were calculated using a computer aided software design connected to the universal testing machine. Then, all samples were subjected to stereomicroscopic examination to examine the nature of bond failure. Finally, randomly selected samples from each subgroup were subjected to scanning electron microscope for evaluation of morphological characteristics changes.

CONCLUSION

CONCLUSION

Within the limitations of this study it was observed that,

- NaOCl had a positive influence on the bond strength of bioceramic root repair materials.
- The biodentine had a negative influence on exposure to saline.
- The moisture present in the dentinal tubules was not adequate for the setting reaction of ERRM. The material started to set only when completely covered by water. Thus, additional moisture is required for the setting reaction of ERRM.
- The setting time of ERRM was not 4hrs as per the manufacturers instruction especially in a dry environment.
- None of the samples in this study had undergone an adhesive mode of failure.
- Majority of the samples predominantly showed cohesive mode of failure. However the control group showed a mixed mode of failure.

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ANNEXURE

APPENDIX I

INSTITUTIONAL ETHICAL COMMITTEE

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KSR Kalvi Nagar, Tiruchengode.

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Human Activist

Dr.R.Renuka,M.D.S.,(Perio),M.Sc.,
Family Counsellor

Dr.K.Sivakumar,MDS.,(Cons.Dent.)

Dr.Suman, M.D.S.,(OMDR)

Dr.Sharath Ashokan,MDS.,(Pedo)

Dr.G.Rajeswari,Ph.D.,(Biochemistry)

Dr.K.Karthick,MDS.,(Cons.Dent.)

Mr.V.Mohan,M.Sc.,M.Phil.,(Physicist)

Mr.A.P.S.Raja,B.A.,
(Layperson)

Ref.: 117 /KSRIDSR/EC/2015 **Date : 19.12.2015**

To

Dr.M.Abitha Banu,
Postgraduate Student,
Dept. of Conservative Dentistry & Endodontics,
KSR Institute of Dental Science & Research,

*****

Your dissertational study titled "EFFECT OF SODIUM HYPOCHLORITE ON PUSH-OUT BOND STRENGTH OF BIODENTINE AND ENDOSEQUENCE BIOCERAMICS ROOT REPAIR MATERIAL ON FURCAL PERFORATION – AN IN VITRO STUDY" presented before the ethical committee on 15th Dec. 2015 has been discussed by the committee members and has been approved.

You are requested to adhere to the ICMR guidelines on Biomedical Research and follow good clinical practice. You are requested to inform the progress of work from time to time and submit a final report on the completion of study.

Signature of Member Secretary
(Dr.G.S.Kumar)

APPENDIX II

URKUND

Urkund Analysis Result

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Instances where selected sources appear:

13

APPENDIX III

CERTIFICATE - II

This is to certify that this dissertation work title **" Effect of sodium hypochlorite on the push-out bond strength of biodentine and endosequence bioceramic root repair material on furcal perforation – An in vitro study"**

of the candidate **Dr.Abitha Banu .M.** with registration number **241517401** for the award of "**Master of Dental Surgery"** in the branch of **Conservative Dentistry and Endodontics**. I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **3 %** percentage of plagiarism in the dissertation.

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